SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

JULY 1898.

GENERAL PHYSICS.

737. *Vortex Motion.* Part III. **W. M. Hicks.** (Roy. Soc. Proc. 62. pp. 332–338, 1898.)—The writer describes a new system of spiral vortices. Suppose an infinitely long cylindrical vortex of sectional radius a, with internal velocity perpendicular to the axis $v=f(r)$, where $f(0)=0$. Externally, $v=V\frac{a}{r}$ and $V=f(a)$. Again, suppose a motion parallel to the axis inside, the fluid being at rest outside. The velocity will then be internally $u=F(r)$, with $F(a)=0$, and externally zero. The two motions superposed lead to steady motion with vortex filaments in the shape of helices lying on concentric cylindrical surfaces. The writer's problem is to conceive a similar superposition of two motions in the case of any vortex aggregate symmetrical about an axis.

For a particular case of spherical aggregate it is found that the motion in meridian planes is determined by a function ψ, the differential equation of which is

$$\frac{d^2\psi}{dr^2}+\frac{1}{r^2}\frac{d^2\psi}{d\theta^2}-\frac{\cot\theta}{r^2}\frac{d\psi}{d\theta}=\rho^2F-f\frac{df}{d\psi},$$

where F and f are functions of ψ.

In a particular case fully treated, in which F is uniform and $f=\lambda\frac{\psi}{a}$,

$$\psi=A\left\{J_2\left(\frac{\lambda r}{a}\right)-\frac{r^2}{a^2}J(\lambda)\right\}\sin^2\theta.$$

As λ increases we get a periodic system of families of aggregates differing from one another in the number of layers and equatorial axes they possess. The properties of these families are discussed.

The writer further considers the question whether the theory throws any light on the vortex atom theory of matter. It is pointed out, firstly, that the quantitative theory developed in the paper assumes a surrounding irrotational ether, which cannot be the case in nature; secondly, that the results refer only to spherical aggregates—that is, to an artificial assumption. Nevertheless some general conclusions are drawn as highly probable: *e. g.*, that the metals belong to aggregates having an even number of layers or axes, *i. e.*, as shown, the outer rotational motion is opposite to that of the centre. It is found also that the moment of momentum due to the gyrostatic effect rises and falls with the volume of the atom. S. H. B.

738. *Mathematical Theory of the Top.* **Carl Barus.** (Science, 7. pp. 469–474, 1898.)—This is a review, by Barus of F. Klein's four lectures. According to Barus, Lecture I. introduces four new parameters, as follows:—The top is first supposed to spin on a fixed point of support. Let xyz and XYZ be points on a fixed and a movable sphere respectively, each of radius r and in congruence. Then, if

$$\zeta=\frac{x+iy}{r-z}=\frac{r+z}{x-iy}\quad\text{and}\quad Z'=\frac{X+iY}{r-Z}=\frac{r+Z}{X-iY},$$

ζ and Z are two parameters, each of which determines a point on the fixed or movable sphere. The relation between ζ and Z' is then

$$\zeta=\frac{\alpha Z'+\beta}{\gamma Z'+\delta}\quad\text{and}\quad \alpha\delta-\beta\gamma=1.$$

The four new parameters are $\alpha, \beta, \gamma, \delta$. The Eulerian coordinates ϕ, ψ are expressed in terms of these parameters. Then the Z pole of the moving sphere is selected, at which $Z=\infty$, and at this point $\zeta=\alpha/\gamma$. Hence ζ is at once expressible as a single quotient of single-valued σ functions with an exponential time-factor. Thus is effected a great simplification of the problem.

The rolling and fixed cones, or polhode and herpolhode, are then investigated. It is shown how a free body in hyperbolic non-Euclidean space may be so fashioned in real time as to carry out the actual motion of the top.

In the fourth lecture the restriction that the top shall spin on a fixed point of support is removed. S. H. B.

739. *Principle of Physical Development.* **O. Wiedeburg.** (Annal. Phys. Chem. 63. 1. pp. 154–159, 1897.)—The author shows that complete cyclical processes are not possible in bodies covered by his fundamental equations. It never happens that all the conditions of a solid body revert to the same point at the same time; they are, so to speak, displaced with respect to each other. The body as a whole, as far as its quantitative conditions are concerned,

is ever a new one. It "ages," and never returns altogether to its previous state. Such irreversible processes probably occur also in liquids and gases. E. E. F.

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740. *Relative Motion of the Earth and Ether.* **W. Sutherland.** (Phil. Mag. 45. pp. 23–31, 1898.)—In the experiment of Michelson and Morley a beam of light is split into two parts, which, after travelling backwards and forwards along equal paths at right angles, return to the parting place in such a condition as to produce interference-fringes. If the earth is moving relatively to the ether, and one of the paths is in the direction of the relative velocity v, while the other is at right angles to it, then, if V is the velocity of light and 2D the distance travelled by the beams between parting and meeting again, the actual paths, instead of being equal, differ by Dv^2/V^2. If now the whole optical apparatus is turned through a right angle the same difference accrues, but in the opposite way, so that the total difference obtainable by contrasting the two cases is $2Dv^2/V^2$, and ought to produce a corresponding displacement of the interference-fringes as seen in the two positions of the apparatus. Michelson and Morley aimed at making their optical adjustments so sensitive that the alteration in the fringes would be definitely measurable, although when v is equal to the earth's velocity in its orbit v^2/V^2 is as small as 10^{-8}. The result of their measurements was to make it appear as if $v=0$, that is to say, that the earth carries the ether with it: a dilemma for physicists. The author urges that there is one assumption in the theory of the optical part of the experiment which has not been provided for in the actual arrangements; namely, that the line which is common to the two wave-fronts of the divided beam when the two meet again is of identical origin in each wave-front, that is to say, that one line in the wave-front before division has the said common line as its representative in both wave-fronts. It is pointed out that under the experimental conditions a lateral shift of the one front relatively to the other can occur; and though minute, may still be large enough to make the optical apparatus much less sensitive than it was supposed to be. In this case the experiment, instead of proving that $v=0$, may only prove that the apparatus had not been made of the order of sensitiveness to measure the minute v^2/V^2. To get the sensitiveness up to the Michelson and Morley ideal, it will be necessary to make the lateral shift small enough or to get the axis of symmetry of the fringe system into the field of view, either of which may prove a tedious adjustment to realise practically. AUTHOR.

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741. *Diameter of Venus.* **K. Strehl.** (Zeitschr. Instrumentenk. 18. pp. 43–49, 1898.)—The paper deals with the observed differences in the diameter of the planet, first, when measured in the ordinary way, the disc of the planet being bright on the darker sky, and second, when measured during a transit

of the planet across the sun, when it appears as a black spot on the bright photosphere. Both halation and diffraction affect the measures, and these quantities are very different in the two cases. C. P. B.

742. *Viscosity of Solids.* **A. Heydweiller.** (Annal. Phys. Chem. 63. 1. pp. 56–60, 1897.)—The viscosity of menthol was determined in the solid and liquid states to obtain some information on the changes which this property undergoes with rise of temperature and change of state. The method adopted for the solid state consisted in blocking a glass tube with a plug of the solid menthol, and measuring the rate of displacement due to a difference of pressures on the two sides. The tube on one side of the plug was connected to a vertical tube of finer bore, and all the space on that side of the plug, including the vertical tube, was filled with mercury. The space on the other side of the plug was evacuated. The rate of displacement of the menthol was registered by the rate of fall of mercury in the vertical tube.

The curve showing the variation of viscosity with temperature consists of two parts—that for the solid, and that for the liquid conditions. Both parts are approximately straight. The temperature-coefficient for the solid state is very great, amounting to 20 °/₀. The viscosity in the solid state is 10^{11} times that in the liquid state. J. B. H.

743. *Apparatus for Constant-Temperature Water-Current.* **C. Pulfrich.** (Zeitschr. Instrumentenk. 18. pp. 49–52, 1898.)—Water, taken from the supply-pipes, is first brought to a pressure-regulator consisting of a cistern with overflow-pipe, the supply being so regulated that there is always a small overflow. It is then led through a copper heating spiral, 3½ metres long, coiled between two vertical metal cylinders, open below and closed above. A Bunsen burner is placed under the inner cylinder, the hot gases issuing through holes at the top and descending between the cylinders. The hot water, after doing its work, is led to a second cistern with an overflow-pipe for discharge. To avoid air-bubbles collecting, the water should flow upwards in the heating spiral and in the succeeding tubes. A gas regulator is not necessary, unless there be considerable variations in the pressure of the gas-supply. The author claims that this apparatus will maintain a constant temperature for an hour within a few tenths of a degree. A fine adjustment of the temperature is made by varying the difference of level between the two cisterns.

G. H. Ba.

744. *Constant Temperature Device.* **K. P. Cady.** (Journ. Phys. Chem. 2. pp. 242–244, 1898.)—Illustrated description of an apparatus for large operations, worked by a turbine. S. G. R.

745. *New Integraph.* **A. H. Barker.** (Mech. Eng. 1. pp. 304–305, 1898.)—A frame mounted on three wheels, to run from left to right, carries two pencil carriages which run up and down. The upper carriage carries the integrating wheel, which rolls on the paper. The lower carriage carries a tracing-point P, which is moved over the curve to be integrated. A tangent-bar is arranged so that the tangent of its angle of inclination is proportional to the ordinate to P. The plane of the integrating wheel is always kept parallel to the tangent-bar. If the tracing-point P move over a curve $y=f(x)$, a pencil Q attached to the upper carriage will trace out the curve

$$y = \int f(x)\,dx.$$

A. S.

LIGHT.

746. *Analogy between Pendulum Motion and Light.* **E. Ketteler.** (Annal. Phys. Chem. 63. 1. pp. 72–77, 1897.)—This is a mathematical paper, showing an analogy between the equations of motion of a vibrating pendulum left to itself under certain damping forces and the passage of light into a transparent medium. In a transparent medium with increasing angle of incidence a similar discontinuity occurs for the light vibrations as occurs for the oscillations of the pendulum by increase of the damping coefficient. J. B. H.

747. *Optical Constants of Sodium.* **P. Drude.** (Annal. Phys. Chem. 64. 1. pp. 159–162, 1898.)—The refractive index n and the index of absorption κ were measured by the method of reflection, the sodium being enclosed in a glass cell containing an atmosphere of hydrogen. The apparatus used was the same as in a former investigation by the author (Annal. Phys. Chem. 39. p. 381, 1890). The values obtained for sodium with sodium light are

$$n\kappa = 2{\cdot}61; \qquad n = 0{\cdot}0045; \qquad \kappa = 580.$$

From the value of n it appears that the velocity of light in sodium is 220 times greater than in air. The author thinks the errors of observation might allow the value of n to be as high as 0·054, which is still the smallest refractive index known, the next being sodium-potassium alloy and the next again being silver ($n = 0{\cdot}18$). J. B. H.

748. *Optical Properties of Hydrophane.* **J. Stscheglayew.** (Annal. Phys. Chem. 64. 2. pp. 325–332, 1898.)—Hydrophane is a whitish mineral resembling opal. It is capable of absorbing liquids, and thereby becoming perfectly transparent. In doing so, its refractive index changes, and it is found to be such as would result if two liquids, having the refractive indices of hydrophane and the liquid experimented with, had been mixed together in the same proportions. Hence the solid body behaves in this case like a liquid, and its refractive index may be found by mixing two liquids of known refractive indices until their joint index equals that of the moistened hydrophane. Such a mixture is that of 29 per cent. of toluol and 71 per cent. of alcohol, with a refractive index of 1·46. E. E. F

749. *Lambert's Law.* **F. Kolaček.** (Annal. Phys. Chem. 64. 2. pp. 398–408, 1898.)—The author compares his own theory of diffused reflection with that of Uljanin, which is based upon Kirchhoff's theory. The latter is founded upon the two laws of thermodynamics and upon the hypothesis that absolutely black bodies exist. But such black bodies do not exist, at least not when

they are to possess smooth surfaces. For even if the refractive index of the body with respect to the medium is unity, these bodies always reflect light to an extent proportional to their absorption and to the angle of incidence. For vertical incidence the reflection factor is $\sigma^2(4+\sigma^2)$, where σ is the refractive index. But it is not certain that the hypothesis of an absolutely black body is essential to the truth of Kirchhoff's theory. The author's theory is a purely optical one, but involves an hypothesis concerning the amplitude of the radiation inside a glowing body. It gives better results, with the best constants, than Uljanin obtains with his calculations. E. E. F.

750. *Improvements in Telescopes.* **C. Dévé.** (Comptes Rendus, 126. pp. 636–640, 1898.)—Certain arrangements and devices for the improvement of "autocollimating" telescopes are described; also modifications which enable the optical verification of the parallelism of portions of straight lines or planes to be carried out, even when the latter are not face to face, so that the ordinary methods cannot be applied. The arrangements can best be understood from the diagrams given by the author in the paper. J. J. S.

751. *Index of Refraction of Compressed Gases.* **P. Carnazzi.** (N. Cimento, 6. pp. 385–400, 1897.)—The gases studied are air, hydrogen, and carbon dioxide. They are contained in a prism with glass sides. The prism is not placed on the table of a spectrometer, nor in the position of minimum deviation, but means are taken to determine the angle of the prism, the angle of incidence, and the angle of emergence. From these data, n, the index of refraction, can readily be calculated. A few typical results are given in the tables below. The second column in each table gives the value of n_0-1, the refractive power reduced to the *mean* temperature, and to the pressure of the first experiment. To effect this reduction the author employs the formula $(n_0-1)/\delta_0=(n-1)/\delta_H$, δ_0 being the density of the gas under consideration in the conditions of the first experiment, and δ_H the density of the same gas at the temperature and pressure of the particular experiment. For Gladstone's law to be exact, $(n-1)/\delta_H$ should be a constant, and the values of n_0-1 should not vary for the same gas. With air and hydrogen the value of (n_0-1) increases with augmentation of pressure, whilst it decreases in the case of carbon dioxide.

Air.

Atmospheric Pressure 769·8 mm.	Mean temperature 12°·1.
Pressure in mm.	$(n_0-1)1000$
769·8	
5,264·74	0·31318
7,631·57	0·31842
10,527·79	0·32687
14,536·90	0·33554
37,627·82	0·36092

Hydrogen.

Atmospheric Pressure 770·4 mm.	Mean temperature 13°.
Pressure in mm.	$(n_0-1)1000$
770·4	
6,794·24	0·15753
11,714·7	0·17224
13,869·5	0·17225
20,296·2	0·18519
37,657·9	0·19127

Carbon dioxide.

Atmospheric Pressure 770·95 mm.	Mean temperature 13°·3.
Pressure in mm.	$(n_0-1)1000$
770·95	
1,696·14	0·44594
4,240·39	0·44155
7,309·59	0·43457
10,435·2	0·43184
19,779·2	0·4049

A. Gs.

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752. *Diffraction Phenomena in the Focal Plane of a Telescope.* **H. Nagaoka.** (Phil. Mag. 45. pp. 1–23, 1898.)—The author gives in the first place a general discussion of Fraunhofer's diffraction-phenomena of a circular aperture for a finite source of light, and shows how the intensity of illumination in the focal plane can be mechanically evaluated for a luminous source having any given shape. He then considers the intensity both inside and outside of a circular image. It is then shown how by the superposition of two systems of lines of equal intensity the formation of a ligament during the ingress or egress of a dark disc from a luminous source can be explained, as has been verified by the experiments of André and Angot. For practical purposes it is sometimes convenient to draw the lines of equal intensity. For a circular source of light they consist of a series of concentric circles, which if drawn for equal difference of intensity crowd together near the geometrical edge. When there are different sources of light the separate effects can be superposed and the distribution of illumination graphically represented in the following manner:—Draw the lines of equal intensity for the image of each source; at the point of intersection of any two lines the intensity will be the sum of the two. A system of points of equal intensity is thus obtained. By drawing the lines at small intervals a sufficient number of points can be found to draw curves of equal intensity,

which will represent the distribution of illumination due to different sources. In fact the process of drawing the lines of equal intensity is analogous to that of drawing equipotential lines. Suppose that the luminous source is a circular disc, on which there is a small dark circular space touching the rim of the disc. The image as seen through a telescope will form a drop, as the following consideration of the lines of equal intensity will show. Such a source may be imagined as produced by the superposition of two different sources, one of which consists of a circular disc of uniform intensity without any dark space, while the other consists of a circular disc occupying the place of the dark space, and of such intensity that it is equal but *of opposite sign*. This consideration immediately gives the solution of the problem either as mathematical formula or as graphical representation. For the latter purpose concentric circles are drawn representing lines of equal intensity for the luminous source, and similar lines of equal *negative* intensity for the imaginary source occupying the dark space; a series of lines of equal intensity due to these sources can thus be got. Diagrams are given by the author illustrating the case. From inspection of the figures it appears that when the dark space is in geometrical contact with the edge of a luminous source, it appears as a dark protuberance projecting from the surrounding dark space. With the receding of the dark space towards the interior of the luminous source, the connecting ligament becomes thinner, and finally disappears. The inner dark disc is, however, a little elongated, and assumes a pea-shaped appearance; while the external dark space bulges out towards the luminous source. The change is only transient; with further ingress the dark disc becomes circular, and the swelling of the external dark space vanishes. Thus to the first approximation the explanation of drop formation during the transit of inferior planets is arrived at. If the dark space be taken nearly equal to the luminous source and have small protuberances, by a similar process a result is obtained which has a close analogy with Baily's beads. J. J. S.

753. *Artificial Temporary Colour-Blindness.* **George J. Burch.** (Roy. Soc. Proc. 63. pp. 35–38, 1898.)—The author describes how temporary blindness to light of a given colour is produced by exposing the eyes to light of that colour. When temporary colour-blindness has been induced to light of some particular colour, the other colours of the spectrum are surveyed, and the effects are described. Thus, when yellow blindness is induced and the spectrum viewed, the whole of the red and the whole of the green are affected. These experiments lead the author to the conclusion that no one colour-sensation is related to any other in the sense indicated by Hering. Each may be exhausted without affecting the others, and the observed facts are considered to be more in accordance with the Young-Helmholtz theory, but the existence of a fourth colour-sensation, namely, blue, is implied. T. P.

754. *Spectroscope without Prisms or Gratings.* **A. A. Michelson.** (Amer. Journ. Sci. 5. pp. 215–217, 1898.)—It is possible to construct gratings which shall throw a large proportion of the light in very high orders of spectra—say the hundredth—in which case the grating-space must be of the order of a hundred waves, or, say, twenty to the millimetre instead of a thousand. Instead of ruling deep grooves on glass, a grating may be built up of a number of equally thick plates pressed together and sheared through an angle of 45° or other angle, the projecting edges of which make ridges and grooves of constant dimensions. Since the resolving power is independent of the number of plates, but depends only upon the total thickness and the order of the spectrum picked out, a small number of elements, say twenty 5 mm. thick, suffices to give a dispersion of 100,000. The Zeeman effect is readily observed with such an apparatus. The only advantage of narrower grooves lies in the better separation of successive spectra. E. E. F.

755. *The Modifications of the Spectra of Substances radiating in a Magnetic Field.* **T. Preston.** (Roy. Soc. Proc. 63. pp. 26–31, 1898.)—The author gives an account of observations made during an investigation of the influence of a strong magnetic field on the spectral lines of various substances. The spectra were photographed under the influence of the magnetic field, and the photographs show that the spectral lines are very differently affected, even for the lines of the same substance. Iron, being a mangetic substance, was especially examined, but no special peculiarity marked its spectrum, and the same may be said of gases. The effect, as measured by the distance between the side lines of the triplet viewed across the lines of force, or of the components of the doublet viewed along the lines of force, appears to be no simple function of the wave-length, being often widely different for lines of approximately the same wave-length, nor does this effect appear to be in any way parallel to the pressure effect observed by Messrs. Humphreys and Mohler. AUTHOR.

756. *Connection between the Faraday and Zeeman Effects.* **Geo. F. FitzGerald.** (Roy. Soc. Proc. 63. pp. 31–35, 1898.)—The author connects the rotation of the plane of polarisation of plane polarised light passing through matter placed in a magnetic field with the changes of frequency produced when the source of light is placed in a strong magnetic field. That is, the change of velocity produced in the former case is connected with the change of frequency produced in the latter. Starting with the idea that the dispersion in the spectrum is controlled by a strong absorption-band in the ultra-violet, it follows that if this absorption-band be changed by any cause, the dispersion will also be altered, and with it the velocity of light in the spectrum, so that the change of frequency and the change of velocity, that is the Zeeman and the Faraday effects, become connected by any form of general

dispersion theory connecting the frequency and velocity. The equation deduced is of the form

$$\mu^2=\mu_0^2+\frac{a}{\lambda^2}\pm\frac{a}{\lambda}\cdot\frac{\rho\mathrm{H}}{2\pi\mathrm{V}_0},$$

and this is shown to lead to appproximately the same value of the effect as has been observed experimentally. T. P.

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757. *Radiation in a Magnetic Field.* **H. A. Lorentz.** (Annal. Phys. Chem. 63. 1. pp. 278–284, 1897.)—Assume that a luminous molecule may be regarded as a dynamical system depending upon n normal coordinates θ_r and oscillating about a position of stable equilibrium, so that $2\mathrm{T}=\Sigma a_r\dot{\theta}_r^2$, $2\mathrm{U}=\Sigma b_r\theta_r^2$, and the frequency k_r of a typical vibration is $\sqrt{(b_r/a_r)}$. Neglecting the magnetic forces called into play by the moving ions themselves, the equations of motion in a magnetic field will be

$$a_r\ddot{\theta}_r+b_r\theta_r+\sum_s c_{rs}\dot{\theta}_s=0,$$

where $c_{rs}+c_{sr}=0$. Put $\theta_r=\mu_r e^{ilt}$ and eliminate the quantities μ_r: the result is an equation in l, the frequency of a principal vibration in the disturbed motion. If $k_1, k_2, \ldots k_n$ are all different, the value of l_1 (corresponding to k_1) is approximately

$$l_1-\tfrac{1}{2}\delta,$$

where

$$\delta=\left[\frac{c_{12}^2}{a_1a_2(k_2^2-k_1^2)}+\frac{c_{13}^2}{a_1a_3(k_3^2-k_1^2)}+\ldots+\frac{c_{1n}^2}{a_1a_n(k_n^2-k_1^2)}\right]k_1.$$

Suppose now that in a source of light there are a large number of equal and similar but differently oriented luminous particles. Then by taking normal coordinates for each, the above analysis applies to all, but the coefficients c are different, and δ will acquire values between two fixed limits; consequently the spectral line will undergo a widening and also, in general, a lateral displacement. The effect depends upon the square of **H**, and is probably too small to be observed in such fields as are practically obtainable.

Suppose now that $k_2=k_1$, all the other k's being different; there will be two corresponding values of l, which are approximately

$$k_1\mp\frac{c_{12}}{2\sqrt{a_1a_2}},$$

and the change is comparable with the first power of **H**.

To explain the Zeeman effect on these principles, we must suppose (i) that three principal vibrations have the same period, and (ii) that the influence of the magnetic force does not depend upon the orientation. On these assumptions, taking $k_1=k_2=k_3$, we have for the corresponding disturbed motion three frequencies, k_1 and

$$k_1 \pm \frac{1}{2}\sqrt{\left(\frac{c_{12}^2}{a_1a_2}+\frac{c_{23}^2}{a_2a_3}+\frac{c_{31}^2}{a_3a_2}\right)},$$

where the quantity in brackets is of the form $C(H_x^2+H_y^2+H_z^2)$.

G. B. M.

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758. *Partial Polarisation of Light in a Magnetic Field.* **H. A. Lorentz.** (Écl. Électr. 14. pp. 311–313, 1898.) [*Cf.* Kon. Ak. van Wetenscheppen (Academy of Sciences of Amsterdam), vi. pp. 193–209, 1897.]—1. This paper is an abstract and discussion by **A. Cotton** of Lorentz's views based on the experiments of Egoroff and Georgiewsky, in which they discovered the partial polarisation of light emitted normally to the lines of force by a flame placed in a magnetic field. Lorentz has repeated the experiments, and has verified the fact that the partial polarisation is manifested in a relatively feeble magnetic field (of the order 1·0 C.G.S.). With an intense field he finds the proportion of the light polarised to be about 12 °/₀ of the total light emitted. This agrees with the result of Egoroff and Georgiewsky. Moreover, he finds that it is the vibrations normal to the field which are the important ones.

2. Lorentz seeks then to connect together these experiments and those of Zeeman, and his own theory on the motion of ions in a magnetic field. Designating by I_1, I_2, I_3, the intensities perpendicular to the lines of force, of the three components of the triplet observed by Zeeman, of which the periods are T_1, T_2, T_3, we should have $I_1+I_3>I_2$, so that one is led to ask if the circular motions of the ions which produce the lateral rays of periods T_1, T_3, and the rays of same period of the doublet observed in the direction of the lines of force, have more importance than the vibrations parallel to the lines of force which have kept the original period T_2. *A priori* it seems as if in a magnetic field the circular vibrations should be privileged. One is even led to ask if the two circular vibrations which have the one the sense of the amperian currents, the other the contrary sense, have the same intensity. On examining the light emitted in the direction of the lines of force in which alone the two sorts of circular vibrations propagate themselves, Lorentz does not find any sensible difference of intensity between them. He employs a quarter-wave plate which would transform the polarisation rectilinearly, so that it may be detected by an ordinary polariscope. Lorentz besides remarks that his theory predicts nothing of the sort. Calling r the change of period

$$T_1=T_2+r, \quad T_3=T_2-r,$$

the intensities I_1, I_3 should not differ from $I_2/2$ except by a very small fraction, of the order $\frac{r}{T}$, which would be quite imperceptible.

3. Thus the phenomenon of Egoroff and Georgiewsky would seem to contradict the theory of Lorentz. But Lorentz makes the following very important remark:—The intensity really observed depends not only on the vibratory state *at a point* of the source, but also on the *absorption* that the vibrations experience whilst traversing the successive layers of the flame. In particular, the vibrations proceeding from the hinder part of the flame are enfeebled by their passage towards the front part. When the magnetic field is excited this absorption should diminish, according to Lorentz, for the vibrations perpendicular to the field which alone experience the change of period. Admitting that each component of the triplet is given by a determinate group of ions, a first group of ions A_2 would be composed of the ions vibrating parallel to the lines of force with the period T_2; two other groups would vibrate in a plane perpendicular to the lines of force, with the periods T_1, T_3 respectively.

The absorption of the vertical vibrations (those perpendicular to the field) proceeding from the posterior part of the flame, and which have the period T_1, is produced only by *one* of the groups of ions, the group A_1, formed of ions which have precisely the same period. If the field is suppressed, this absorption is produced by two groups of ions A_1, A_3, since the periods T_1, T_3 then coincide with the original period T_2. The same remarks apply to the vertical vibrations of period T_3. On the other hand, the vibrations parallel to the lines of force, of period T_2, would be absorbed in the same way within the field, and outside it (by the ions A_2); for *Lorentz admits that even outside the field the absorption of a polarised ray is produced solely by those of the ions which vibrate in the plane of vibration of the incident ray.* Natural light observed outside the field would then be transformed into light partially polarised in a horizontal plane, conformably to experiment.

4. Lorentz makes the following experiment to show that the absorption in the flame placed in the field can produce a partial polarisation. A flame F_1 is placed in the field (13,000) of the electromagnet. The flame is feebly charged with sodium. A second sodium flame F_2, limited by a diaphragm, is placed behind the first on the straight line perpendicular to the field along which the observer looks. On observing, with Savart's polariscope, the diaphragm placed against F_2, sharply defined fringes appear on its surface, indicating that the light of this flame F_2 is polarised by its passage across F_1. The polarisation is of the same sense, but more marked than that of the light sent out by F_1; it is perceived even when the light from F_1 is too feeble to be studied by the polariscope.

5. In certain circumstances, for instance when repeating the experiment with a flame F_2 which is very intense, a polarisation contrary in sense to that from F_1 has been observed; then it is the horizontal vibrations which produce the result. The author interprets this experiment by remarking that the rays in the light of F_2 are then very broad, broader than the entire triplet given by

the flame in the field. The vertical vibrations of period T_1, T_3 contained in the light of F_2 are then absorbed by the ions A_1, A_3.

6. In the remainder of the paper Lorentz develops certain calculations on the theory of motion of the ions in the magnetic field. He neglects completely in his calculations the inertia of the ether. [*Cf.* Poincaré, L'Écl. Électr. 11. p. 481.] He examines the influence of the variable period during which the field becomes established. The formula which is arrived at, and which gives the absolute change of period, is:

$$\tau = \frac{eH}{4\pi m} T^2,$$

where T is the original period, H the field, $\frac{e}{m}$ the ratio of the charge of the ion (in E.M. units) to its mass. According to this formula the *absolute* change of period would be, *for a given ion*, proportional to the square of the period and *independent of the temperature*. The last point especially appears accessible to experiment. J. J. S.

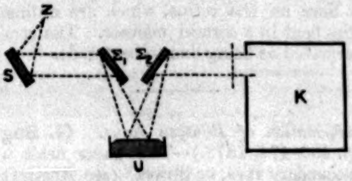
759. *Polarisation of Light in a Magnetic Field.* **A. Cotton.** (Écl. Électr. 14. pp. 299–300, 1898.)—The author discusses the experiments of Egoroff and Georgiewsky (see Phys. Soc. Abstracts, Nos. 382, 461, & 577, 1897), and the explanation of these given by Lorentz (Abstr. No. 758). These experiments may be easily repeated, but it is essential that a flame but slightly charged with sodium, and thus moderately bright, be used. The author mentions several forms of polariscope which may be used to view the fringes.

Lorentz implicitly makes a new enunciation of the principle of Kirchhoff; instead of the usual statement that a vapour absorbs the radiations which have the same period as the radiations which it emits, it is necessary to say that a vapour absorbs the radiations which have the same period and the *same direction* as its own vibrations. Perhaps this is the correct enunciation of the law of Kirchhoff, *at least when the absorbing layer is placed in a magnetic field*. In this case the vibrations of a certain period which are produced have necessarily a determined direction or sense, and are in some sort *forced*. J. J. S.

760. *Polarisation of Light by Rubber.* **A. H. Bruère.** (Phys. Rev. 6. pp. 140–152, 1898.)—At an angle of 58° the polarisation of yellow light by hard rubber or ebonite is as complete as polarisation by glass, where the maximum occurs at 56°. This result does not agree with those of Jamin, who found that only a few substances completely polarise light by reflection, and that for these $\mu = 1{\cdot}46$. The refractive index of hard rubber for sodium light, as determined from the angle of polarisation, is 1·6. The completeness of the polarisation suggests the use of hard rubber as a substitute for black glass in polarising apparatus. E. E. F.

761. *Radiation of a "Black" Body.* **O. Lummer** and **E. Pringsheim.** (Annal. Phys. Chem. 63. 1. pp. 395–410, 1897.)—The authors attempt to realise Kirchhoff's conception of an equivalent to an absolutely black body in the shape of a uniformly heated hollow space with a small opening, and test Stefan's law, which maintains that the radiation of such a body is proportional to the 4th power of its absolute temperature. Different temperatures, ranging from 100° to 1300° C., are produced by boiling water, by a mixture of potassium and sodium nitrates, and by an oxy-coal gas flame. Radiations are measured by the bolometer. The Stefan-Boltzmann law is confirmed to within 3 to 8 $^{\circ}\!/_{\circ}$. All the differences between the theoretical and experimental values would be eliminated by substituting 3·96 for 4 as the index of the absolute temperature. E. E. F.

762. *Heat-Rays of Great Wave-Length.* **H. Rubens** and **E. Aschkinass.** (Annal. Phys. Chem. 64. 3. pp. 602–605, 1898.)—It having been found that water-vapour absorbs the infra-red rays transmitted by fluor-spar, it is of interest to enquire whether liquid water does the same. On account of absorption by almost all known substances, the rays must be transmitted through water not contained in a vessel with parallel sides. The arrangement adopted is shown in the diagram. Light from a zirconium burner Z is reflected by a concave mirror S and a plane mirror Σ, on to a mercury-surface U, and then by further reflections into a box K containing the usual fluorspar reflecting surfaces and the thermocouple. After a first reading, a thin sheet of water is laid over the mercury. The absorption is very considerable. The refractive index is of the same order as for the visible spectrum, and the value 9 is probably not reached until $\lambda=24\ \mu$. The comparative intensities of reflected rays obtained with other liquids are: ethyl alcohol 5, carbon bisulphide 23, benzol 49, phenol 5, xylol 9, with a layer 5 mm. thick. It appears that benzol is very transparent for these rays ($\lambda=0{\cdot}5$ to $1{\cdot}8\ \mu$), even more so than chloride of silver. The substitution of a hydroxyl group for a hydrogen atom (phenol) considerably increases the absorption, just as it does in other substances. E. E. F.



763. *Fluorescence and Photoelectricity.* **G. C. Schmidt.** (Annal. Phys. Chem. 64. 4. pp. 708–724, 1898.)—The Wiedemann-Schmidt theory of fluorescence supposes that it is due to the recombination of ions after exposure to light. Since the negative ion is more easily "discharged" in photoelectric bodies than the positive ion, it might be expected that the most highly fluorescent bodies would be the least photoelectric. But no such connection between the two bodies can be established. A brilliantly fluorescent "solid solution" like $SrS+xCu_2S$ is also strongly photoelectric. The haloid salts of silver and sodium agree in not showing any fluorescence. But whereas the silver salts are highly photoelectric, the sodium salts are not at all. It is found, however, that thermoluminescence and photoelectric sensitiveness are invariably associated if either of these qualities is strongly marked.
E. E. F.

764. *Visibility of Röntgen Rays.* **E. Dorn.** (Annal. Phys. Chem. 64. 3. pp. 620–622, 1898.)—That the light effect of Röntgen rays is not due to an act of "accommodation," as has been alleged, has been proved by the author with the aid of a medical friend, who intentionally paralysed the accommodation capacity of one of his eyes with homatropine, and found the visual effect as strong as before. The fact that a straight rod sometimes casts a bent shadow into the eye is explained by considering that Röntgen rays are not refracted by the humours of the eye. The rods therefore cast straight lines on the retina, which are ordinarily only produced by bodies bent in a certain manner. The straight lines are therefore interpreted as being due to bent rods. E. E. F.

765. *Transformation of Röntgen Rays.* **G. Sagnac.** (Écl. Électr. 14. pp. 466–474, 1878.)—This paper deals with the production of "secondary rays, or S-rays" (see Abstract No. 245).
A. D.

766. *Uranite Rays.* **E. Villari.** (L'Elettricista, Rome, 7. 5. pp. 101–103, 1898.)—The paper describes experiments on the property possessed by uranite of discharging electrified bodies. The electrified body was a gold-leaf electroscope, which lost from leakage 1° in 90″. On placing a piece of uranite 1 cm. from the electroscope-knob the loss was 1° in 7″. Sending a current of air transversely between the knob and the uranite slightly reduced the loss to 1° in 8″. To ascertain to what extent the discharging power persists, the uranite was placed in a tube 20 cm. from the electroscope. This lost 1° in 24″ when a current of air or of illuminating gas was directed through the tube against the electroscope-knob. Increasing the distance to 190 cm., the loss was 1° in 54″. The loss without the uranite was 1° in 148″. Further the author found that when a metal point was placed in the air-

current, the phenomena were the same as in the case of gas subjected to Röntgen rays. Without the uranite and with the point to earth, the loss was 1° in 134″; with the uranite, 1° in 25″. With electroscope and point charged to opposite potentials, 1° in 43″; to similar potentials, 1° in 156″. If, however, the charged point were close to the end of the tube and nearly equal in size to its diameter, the discharging power was entirely lost. When the uranite was closed in a paper envelope no action was observable, though an image was obtained on a sensitive plate through black paper after an exposure of 24 hours. G. H. Ba.

HEAT.

767. *Kelvin's Absolute Method of Graduating Thermometers.* **J. Rose-Innes.** (Phil. Mag. 45. pp. 227–234, 1898.)—Kelvin has examined the cooling effects exhibited by various gases in passing through a porous plug; and he found that the effects for any one gas kept at the same initial temperature were proportional to the difference of pressure on the two sides of the plug (Reprinted Papers, vol. i. pp. 333–455). He also found that the cooling effect for air per unit difference of pressure varies as the inverse square of the absolute temperature. It is suggested in the present paper that better results may be obtained by putting

$$\text{cooling effect per unit difference of pressure} = \frac{\alpha}{T} - \beta,$$

where α and β are constants characteristic of the gas, and T is the absolute temperature. The proposed new formula has the further advantage that it applies readily to the cases of carbonic acid and hydrogen. Among the consequences deduced from the formula it is shown that there is no thermodynamic correction needed, for a constant-volume gas-thermometer, involving the first power of the cooling effect. AUTHOR.

768. *Acoustic Thermometer.* **G. Quincke.** (Annal. Phys. Chem. 63. 1. pp. 66–71, 1897.)—This thermometer, which is intended for the measurement of both high and low temperatures, depends for its action on the variation of the velocity of sound in air with change of temperature. The thermometer consists of a wide tube of metal or more refractory substance, closed at one end, which end is placed in the furnace. A vibrating tuning-fork of known frequency is placed at the open end, and the wavelength in the heated air in the tube is measured by finding the nodes and ventral segments produced by interference in the tube. These are located by means of a long thin tube inserted in the other; a rubber tube, connected to the outer end, conveying the sound transmitted through this thin tube to the ear. By moving the thin tube backwards and forwards in the other, the positions of maximum and minimum sound are noted and measured; and, the frequency being known, the velocity is at once determined, and hence also the temperature. J. B. H.

769. *Determination of Vapour-Pressures.* **E. B. H. Wade.** (Roy. Soc. Proc. 62. pp. 376–385, 1898.)—The boiling-points of pure water and of an aqueous solution boiling simultaneously under identical conditions are measured by means of platinum-resistance thermometers. Errors due to variations in the barometric pressure, rate of ebullition, height of flame employed, depth of experimental liquid, and other circumstances are thus eliminated.

The apparatus employed is described in detail. The essential parts are a closed drum consisting of a cylinder of glass the ends of which are closed by plates of tinned brass, and two smaller cylindrical tubes open at one end and terminating below in narrow tubes of brass. These two tubes are fixed side by side within the drum, their narrow tubes communicating with the exterior. These two tubes contain water and solution respectively. The greater part of a current of steam passes directly into the drum jacketing the two tubes, a smaller part of it bubbles through the two liquids, the temperatures of which are read by means of platinum thermometers. Arrangements are provided for keeping the depth of liquid in the two tubes constant or equal, and for maintaining any desired pressure in the drum. The electrical measurements are made in the way described by Griffiths. When the readings of the boiling-points have been completed, a sample of the solution is withdrawn for analysis. T. E.

770. *Vapour-Tension of Mercury.* **L. Pfaundler.** (Annal. Phys. Chem. 63. 1. pp. 36–43, 1897.)—In the experiments the author saturates dry air with mercury-vapour by passing it through tubes containing glass-wool on which finely divided mercury has been deposited. The mercury is then absorbed by passing the air through a tube containing silver foil, the tube being weighed before and after an experiment. The volume of air is measured by a gas-meter, and its temperature of saturation is kept definite by enclosing the mercury-tubes in an air-bath surrounded with the vapour of a boiling liquid. By continuing the experiments for many hours quantities of mercury are absorbed, which can be accurately weighed. The results agree with those obtained by Hertz, within the limits of experimental error. J. B. H.

771. *Vapour-Pressures of Mutually Soluble Liquids.* **W. Ostwald.** (Annal. Phys. Chem. 63. 1. pp. 336–341, 1897.)—This paper contains a theoretical consideration of the vapour-pressures of a mixture of two liquids in the cases when the two liquids dissolve each other, either completely or only partially. By the aid of curves, having for ordinates the vapour-pressures of each liquid and for abscissæ the molecular proportions of the liquid present in the mixture, the author accounts for all the observed phenomena. That mixture of the two liquids which distils unchanged is accounted for by a maximum ordinate in the curve of total vapour-pressure, the ordinates of which are the sum of the ordinates of the other two. The cause of the incomplete mixing of some liquids is accounted for by assuming that here each of the two curves of vapour-pressures possesses a maximum and a minimum ordinate, the maximum of one curve coinciding with the minimum of the other in such a manner that the curve of total pressures assumes where the mixing is incomplete its horizontal straight-line form. J. B. H.

772. *Vapour-Tension of Concentrated Hydrochloric Acid.* **F. B. Allan.** (Journ. Phys. Chem. 2. pp. 120–124, 1898.)—Air was saturated with HCl at 18°·4 C. by bubbling in very fine streams through aqueous solutions of definite strengths, and was then passed through water in Geissler bulbs. The amount of HCl in the latter, and the vapour-tension were then determined and plotted. The curve was found to be regular. If, however, the vapour-tensions be assumed to be proportional to the amount of undissociated HCl, the values for dissociation (as compared also with Kohlrausch's conductivity and Jones's cryoscopic figures, which are also given) will be found to be impossible for such concentrated solutions. Therefore electrolytic dissociation is not an adequate explanation of the fact that HCl solutions do not obey Henry's law. S. G. R.

773. *Measurement of Low Temperatures.* **G. W. Meyer.** (Elektrochem. Zeitschr. 5. pp. 6–10, 1898.)—The paper gives an account of the various methods available for the measurement of very low temperatures—the hydrogen thermometer, thermo-couples, and the platinum resistance thermometer. The author then suggests a method depending on the change of permeability of iron with temperature, and gives a diagram showing the arrangement of connections for use with a ballistic galvanometer. He does not state that he has tried the method, and no experimental data are given. A. H.

774. *Linde's Method of Liquefying Air.* **J. A. Ewing.** (Soc. Arts. Journ. 46. pp. 375–381, 1898.)—The principal part of this regenerative apparatus (fully illustrated in the paper) is a vertical copper worm called an "interchanger," consisting of two concentric tubes, the inner one passing through a nearly closed throttle-valve into a vacuum-jacketed chamber, with which the outer annular space communicates freely. The pressure in the chamber is maintained by a pump at 16 to 50 atmospheres. A second pump compresses the air to 200 atmospheres, and forces it first through a bath of ice and salt to cool it and deposit moisture, then down the inner tube to the aperture of the valve. Kelvin and Joule found that when compressed air expands by passing through a constricted orifice, the temperature falls by about ¼° C. for each atmosphere difference of pressure between the two sides of the orifice. The gas thus expanded and refrigerated escapes upwards through the annular space, and thus effects a cumulative cooling on the high-pressure air which is approaching the valve. A temperature of −200° or under is attained without difficulty, when a portion of the air is liquefied in the chamber, the remainder returning to the pumps. About 0·9 litre of liquid is formed per hour with a continuous expenditure of 3 horse-power. Another form of the apparatus effects the concentration of oxygen to 65 per cent. by the slow evaporation of the liquid air, when the

nitrogen distils first. A new machine for use in the Deacon chlorine process is expected to yield about 1 lb. of liquid air per H.P. hour. An explosive of great power, capable of use with a detonator, is made by pouring the liquid containing 40 to 50 per cent. oxygen on granulated wood charcoal mixed with cotton-wool. In thick cardboard cases it retains its explosive power for 5 or 10 minutes. Trials are in progress at Munich and in a Penzberg coal-mine. S. G. R.

SOUND.

775. *Vibrations of a Rectangular Plate.* **C. Zeissig.** (Annal. Phys. Chem. 64. 2. pp. 360–397, 1898.)—For transverse vibrations of a rectangular elastic plate with free edges no integration of the differential equations has up to the present been successfully carried out. But if two opposite edges are fixed, the vibrations are both practically feasible and amenable to theoretical treatment. The author gives a complete mathematical solution, based upon the fundamental equations established by Voigt, and then proceeds to compare his calculations with actual results. To do this he photographs the glass plates with the theoretical drawings and the actual sand curves. These show a close agreement wherever the theoretical assumptions are fulfilled. The figures due to simple vibrations have the appearance of a grating composed of straight intersecting nodal lines parallel to the edges. The notes have pitches proportional to the thickness and inversely proportional to the square of the side-length of the plates. E. E. F.

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776. *High Pitches.* **A. Appunn.** (Annal. Phys. Chem. 64. 2. pp. 409–416, 1898.)—Defends the correctness of the pitches indicated on his pitch-pipes against the criticism of Stumpf and Meyer. The indications of a recording tuning-fork loaded with a stylus are not reliable, inasmuch as even a scratch with a file will raise the pitch of the smaller forks very considerably. The pitch of the pipe-notes depends of course upon the pressure of the wind, but when they are blown with a certain specified pressure their pitches are absolutely constant for a given temperature. Stumpf and Meyer's assertion that the pipe marked "50,000" gives only 10,000 vibrations per second is probably due to the disturbing effect of combination tones, in which the humming of the wind on entering plays a part. E. E. F.

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777. *Attenuation of Sound.* **A. W. Duff.** (Phys. Rev. 6. pp. 129–139, 1898.)—Theory indicates that the intensity of sound varies as

$$\frac{e^{-2mr}}{r^2},$$

where r is the distance, and m is a factor involving viscosity, conduction, and radiation. Two of these effects increase very rapidly with increase of pitch, while the third, due to radiation, is independent of the pitch. Experiments made with a number of whistles blown separately or together under the same pressure show that eight whistles are, on the average, audible about one-fourth further than a pair of whistles; whereas, if the spherical nature of the wave were the only cause of attenuation, the distances would be as two to one. Since refraction and reflection contribute little to the diminution of intensity observed, it appears that radiation is about seven times as effective as viscosity, and about eighteen times as effective as conduction in reducing the intensity of a note whose vibration frequency is 7000. But for a note of medium pitch, say 350, radiation must far transcend viscosity and conduction in effect, being in fact nearly 3000 times as effective as viscosity, and over 7000 times as effective as conduction. The whole rate of diminution of total energy would, so far as these three causes are concerned, be practically that of radiation alone, or about $\frac{2}{3}$ per cent. per metre.

From the experiments the constant of radiation of air may also be calculated. Its value is about 8·3. It follows that a mass of air at any given excess of temperature above its surroundings will, if its volume remains constant, fall by radiation to one-half of that excess in about one-twelfth of a second. E. E. F.

ELECTRICITY.

778. *Electrical and Hydrodynamical Analogies.* **C. A. Bjerknes.** (Annal. Phys. Chem. 63. 1. pp. 91–96, 1897.)—The author deals in a provisional manner with the probable developments of hydrodynamical analogies as applied to electricity in motion. He points out that the pulsating sphere will have to be retained as the analogue of the uniformly charged body, and that viscosity will have to be called into play in extending the analogy to dynamic electricity. E. E. F.

779. *Measurement of Magnetic Dip and Intensity.* **G. Meyer.** (Annal. Phys. Chem. 64. 4. pp. 742–751, 1898.)—The author describes a simplified method of measuring these quantities. The dip is measured by the earth inductor. A position is sought in the plane of the magnetic meridian at which the revolution of the coil produces no current in the galvanometer. The inductor is kept moving by a belt-and-pulley arrangement, and the presence of alternating currents is tested for by means of a telephone or a capillary electrometer. Every half-revolution of the inductor produces a very audible tick in the telephone, unless the axis of revolution is strictly parallel to the earth's lines of force. The intensity is measured by compensating the earth's field with a known current sent through two large coils surrounding the earth inductor. The latter is exceedingly sensitive to the smallest field-intensity. E. E. F.

780. *Capacity of Condensers.* **F. Lori.** (Roma, R. Accad. Lincei, Atti, 7. pp. 150–157, 1898.)—The object of this research is to find out whether anything analogous to magnetic hysteresis occurs when a condenser is gradually charged up and then gradually discharged. One armature of a Siemens mica condenser (capacity 1 microf.) is put to earth, and the other connected with a quadrant electrometer. The two pairs of quadrants are connected by wires to the poles of a battery, the centre of which is to earth. From a point on the wire joining condenser and electrometer a wire proceeds to a galvanometer; finally, by means of another wire proceeding from the galvanometer, contact can be made with any cell of another battery, the centre of which is to earth. The galvanometer was one of the Siemens type, with four coils and two field-magnets, and was used ballistically. To obtain consistent results, it is necessary first to charge and discharge the condenser a good many times between limits exceeding those of the cycle to be investigated; and between the successive charges (*i. e.* the instantaneous contacts with the different elements of the second battery) a short and constant interval should be allowed to elapse. Under these conditions it is found that, within the limits

of experimental error, the charge of the condenser is proportional to the difference of potential of the armature; so that there is no evidence of "electrical hysteresis." The charge was estimated by adding the successive readings of the galvanometer; the differences of potential could not be observed directly, because the interval between the successive contacts was too short; each potential-difference was calculated from three successive elongations a minute after contact. Accordingly, as the author remarks, what is actually observed is the constancy of V'/q, where q is the charge at time t and V' the potential-difference at time $t+t_0$. However, by another method, to be subsequently communicated, the author has overcome this difficulty, and obtained similar results for mica, paraffin, glass, and ebonite. G. B. M.

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781. *Mutual Influence of Electric Sparks.* **J. I. Károly.** (Annal. Phys. Chem. 62. 4. pp. 612–615, 1897.)—The primary spark-gap is between two electrodes, each of which is connected to a large insulated zinc plate. Parallel to these plates and similarly situated are other two similar plates, attached to which are the electrodes forming the secondary spark-gap, the spark in the secondary gap being due to resonance. The influences on the secondary spark of different forms of electrodes, of the ultra-violet light from the primary spark, of connecting the secondary electrodes to earth both directly and through water-resistances, and of the proximity of the hand to the secondary circuit, are all given in the paper. J. B. H.

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782. *Unipolar Discharges in Rarefied Gas.* **A. Battelli.** (N. Cimento, 7. pp. 81–104, 1898.)—When both electrodes of a vacuum-tube are connected to the same pole of an influence-machine or induction-coil the tube becomes luminous, the luminosity filling the tube with the exception of a single perfectly dark space. This space occupies the centre of the tube if the electrodes are connected to the pole by paths of equal resistance, and increase of resistance in either path causes it to shift towards the side of greater resistance. On bringing an earth-connected body near the tube, the dark space moves away from the body. All these phenomena occur in the same manner whether the pole be positive, negative, or both alternately. The author describes in detail the changes observed in the illumination of the tube as the potential of the electrodes is raised, and as the pressure of the gas is gradually diminished; minor differences exist according as the electrodes are positive or negative. By means of a series of small spherical conductors inserted between the two electrodes, it is found that the potential falls from a maximum at each electrode to zero or nearly so in the dark space. When the gas is very highly rarefied the dark space disappears, the potential becomes uniform throughout the tube, and the characteristic green

fluorescence is seen whether the electrodes be positive or negative; in each case the fluorescence is brightest on the wall of the tube opposite the electrode. The author describes experiments which indicate the existence of anode and kathode rays: both kinds produce fluorescence, but the kathode rays when they impinge on the walls of the tube are reflected or scattered to a greater extent than the anode rays; both kinds are acted upon by a magnet and by an electrostatic field; and both exert a photographic action, that of the anode rays being the more intense. Both rays travel at a speed comparable with that of light. The direction of the magnetic deflection depends on the pressure of the residual gas, and is the same for anode as for kathode rays. The photographic effect of the anode rays is diminished by the presence of a kathode, whereas that of the kathode is increased by the presence of an anode; so that, in the case of ordinary discharges, only the latter action is detected. J. L. H.

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783. *Deflection of Kathode Rays.* **W. Kaufmann** and **E. Aschkinass.** (Annal. Phys. Chem. 62. 4. pp. 588–595, 1897.)—One of the authors has in a previous paper (Wied. Annal. 61. p. 544, 1897) communicated the results of his experiments on the deflection of kathode rays in a magnetic field; and on the assumption that the rays are electrified particles, he calculated the ratio of the mass to the charge. Assuming the value of this ratio, the authors have now calculated the deflection which the rays should undergo in an electrostatic field, and they have experimentally proved that the deflection of the beam on passing near a second kathode in a specially constructed vacuum-tube is in agreement with the calculated value. J. B. H.

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784. *Deflection of Kathode Rays.* **W. Kaufmann.** (Annal. Phys. Chem. 62. 4. pp. 596–598, 1897.)—This paper is a supplement to a former one by the same author (Wied. Ann. 61. pp. 544–552, 1897). In the former one, in calculating the ratio e/m no allowance was made for the variation in the strength of magnetic field from point to point. This variation has now been experimentally determined, and the value of e/m obtained is $1{\cdot}77 \times 10^7$ c.g.s./gramme. J. B. H.

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785. *Kathode Rays.* **E. Wiedemann** and **G. C. Schmidt.** (Annal. Phys. Chem. 62. 4. pp. 603–611, 1897.)—Kathode rays are usually present in two different forms—first, the ordinary slightly conical beam forming a solid cone of rays, and secondly the beam diverging from about the same point as the other but in the form of a conical mantle forming rings or ovals where it meets the tube. The authors have here investigated the cause of the latter and the influences which regulate its form. Its cause is

attributed to rapid oscillatory discharges; and in the experiments the authors used tubes without electrodes, and excited discharges in them by means of a Lecher system of wires. The electrodes consisted of balls or rings pressed against the outside of the tube. The angle of the cone of rays diminishes with the curvature of the glass, increases rapidly with the curvature of the electrode, and increases rapidly with diminution of pressure of gas. The authors suggest the following explanation of these and all similar phenomena:—

(1) Rapid oscillatory discharges in rarefied gases take place near the surface as in metal conductors, but in gases are prevented from reaching the surface by the walls of the tube acting as a kathode, the discharge being thus separated from the walls by a dark kathode space.

(2) The kathode rays leave the surface between the solid and the gas in the direction in which the oscillatory discharge is penetrating that surface. In air at atmospheric pressure the direction in which the oscillations leave a conductor is perpendicular to the surface of the conductor, so that if a metallic sphere is laid against the tube the kathode rays start perpendicular to the surface of the sphere. The angle of the cone only reaches a certain magnitude, owing to the distance between the sphere and the gas in the tube being too great beyond that angle. This critical distance is attained at a smaller angle the greater the curvature of the sphere. If the metal is surrounded by rarefied gas, as is the case with internal electrodes, then the dark space influences the direction in which the oscillations leave the kathode and cause it to be no longer perpendicular to the surface. J. B. H.

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786. *Electrostatic Properties of Kathode Rays.* **P. Lenard.** (Annal. Phys. Chem. 64. 2. pp. 279–289, 1898.)—Experiments carried out on the lines of those made by J. J. Thomson and W. Wien lead to the result that kathode rays behave in every respect as if they consisted of moving particles possessed of inertia and conveying negative electric charges. Kathode rays emerging through a "window" and entering an observation-space, produce an electric charge on any surface on which they impinge, even if the window is put to earth and the observation-space is a perfect insulator. When a field is created between two condenser-plates in the observation-space, the rays are bent towards the positive plate. Those rays which suffer the strongest magnetic deflection also undergo the strongest electric deflection. The velocities of the various rays differ a little. They are probably about one-third of the velocity of light. E. E. F.

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787. *Nodes in Kathode Rays.* **E. Wiedemann** and **A. Wehnelt.** (Annal. Phys. Chem. 64. 3. pp. 606–610, 1898.)—When a magnet is placed opposite the kathode of a vacuum-tube,

or the latter is enclosed in a solenoid, the lines of force are parallel with the rays, and the latter are twisted into a succession of loops or segments which bear some resemblance to those of a vibrating string. The phenomenon may be fully explained by the projected-particle theory of kathode rays. The feebler the field, and the higher the velocity of projection (*i. e.* the potential and the exhaustion), the longer are the corresponding segments. The glow-light is not similarly affected. E. E. F.

788. *Damping of Electric Resonators.* **S. Lagergren.** (Annal. Phys. Chem. 64. 2. pp. 290–314, 1898.)—The damping of a Hertzian resonator may be determined by the method proposed by Bjerknes. But one must take care that the distance between the oscillator and the resonator is so large that no difference is produced in the damping effect by increasing it. The total decrement is due to the development of Joulean heat and to radiation. No energy is given off to the molecules of the surrounding air, unless the E.M.F. is very strong. The damping due to heat may be calculated by means of the old electrodynamics. As regards damping by radiation, the Hertzian resonators may be divided into two classes. The open (rectilinear) resonators show the strongest damping, and seem to obey the simplest laws. The damping of both open and closed resonators decreases as the capacity increases. E. E. F.

789. *Self-Induction of Resonators.* **R. Blondlot.** (Annal. Phys. Chem. 64. 4. pp. 811–812, 1898.)—Points out that in his calculation of the self-induction of resonators in 1891 (Journal de Physique, p. 552) he had omitted the factor 2 in the term containing the mutual induction of the parallel wires. On introducing this term, the systematic errors disappear, and the results agree with those obtained by Mascart. E. E. F.

790. *Electric Vibrations of Long Period.* **J. Bergmann.** (Annal. Phys. Chem. 64. 4. pp. 685–707, 1898.)—The author uses four Rayleigh mercury contacts, two of which are mounted on each arm of a lever which is kept oscillating by a steel spring worked by means of another intermittent current on the Ruhmkorff principle. The four contacts can be inserted either in the charging or the discharging circuit of a condenser. The latter may be charged and discharged any given number of times per second, and the part of the oscillations picked out for measurement is determined by the position of the dippers with respect to the mercury cups. The author succeeded in maintaining a remarkably steady deflection of the galvanometer through a large number of oscillations. E. E. F.

791. *Damping of Electric Oscillations.* **M. Planck.** (Annal. Phys. Chem. 63. 1. pp. 419–422, 1897.)—The damping of electric oscillations in stationary conductors is usually attributed to the resistance of the circuit, in some cases the hysteresis etc. playing an important part. This damping is entirely dependent on the materials composing the circuit, and by a suitable choice of these can be more or less avoided; but there is another damping which is inseparably connected with the oscillations themselves and is not influenced by the materials, namely, that due to the propagation of the energy of oscillation through the surrounding space. This the author calls "conservative" damping, because no energy of oscillation as such is lost. With comparatively slow oscillations the conservative damping is very small, and therefore in the case of the oscillations in a condenser or coil is rightly neglected, but with very quick oscillations, as in the vibrations of light and heat, it plays a very important part. With the object of determining when this conservative damping may be neglected in the case of slow oscillations, the author has calculated it for the cases of an air-condenser and of a solenoid.

A condenser in which oscillations of definite period are excited acts at any point at a distance from the condenser which is great compared with the dimensions of the condenser but small compared with the wave-length of the electromagnetic waves, exactly as an electrostatic "Dipole" of periodically changing moment would do. This case has been investigated by the author in a former paper (Annal. Phys. Chem. 60. p. 593, 1897).

Applying the results of this former paper to the present case, the author obtains for the logarithmic decrement the expression

$$\sigma = \frac{16\pi^4 a^2 C}{3\lambda^3} = 519 \cdot 5 \frac{a^2 C}{\lambda^3},$$

where a is the distance between the condenser-plates, C the capacity of the condenser measured in length-units, and λ the wave-length of the electromagnetic waves.

A solenoid excited by an alternating current acts at distances great compared with the dimensions of the solenoid but small compared with the wave-length of the electromagnetic waves, like a magnetic "Dipole" of periodically changing moment. The expression for the damping when applied to this case becomes

$$\sigma = \frac{16\pi^4 n^2 F^2}{3\lambda^3 P} = 519 \cdot 5 \frac{n^2 F^2}{P\lambda^3},$$

where n is the number of turns on the solenoid, F the area enclosed by one turn, P the self-potential of the solenoid, and λ the wave-length of the electromagnetic waves in the space surrounding the solenoid. J. B. H.

792. *Coherers affected by Sound.* **F. Auerbach.** (Annal. Phys. Chem. 64. 3. pp. 611–617, 1898.)—Metallic coherers acquire

a diminished resistance, not only by the impact of electric waves, but also by the impact of sound-waves. This is shown by placing such coherers on a table with a sounding tuning-fork not far off, with its foot on the table. The diminution of resistance is, as in the electrical case, proportional to the original resistance. Small hard-steel balls show a percentage diminution of resistance amounting to 21 by acoustic influence and 49 by the electric influence of a Righi exciter fed by two cells and giving sparks 15 cm. long. E. E. F.

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793. *Electromagnetic Screens.* **C. Maurain.** (Écl. Électr. 15. pp. 5–8, 1898.)—Cylindrical screens 22 cm. high and 5·6 cm. in external diameter, and of varying thickness, are used made of copper, brass, lead, and a zinc-copper alloy containing a few per cent. of zinc. A coil of wire, concentric with the cylindrical screen, is traversed by a sensibly sinusoidal alternating current, which produces a variable field within the screen, the intensity of which is measured by the current induced in a smaller coil placed concentrically with the larger one. The induced current is measured by a kind of electrodynamometer; the screening action is given by the ratio of the square roots of the deflections with and without the screen. Curves are given showing the decrease of this ratio as the number of alternations per second increases up to 120. With copper the decrease is rapid; with lead and brass it is small; whilst the copper-zinc alloy occupies an intermediate position. The screening action also increases with the thickness of the screen. It is finally indicated briefly that the results are in conformity with the mathematical theory. T. E.

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794. *Anomalous Electric Dispersion.* **P. Drude.** (Annal. Phys. Chem. 64. 1. pp. 131–158, 1898.)—This paper contains a mathematical discussion of anomalous dispersion, (i.) from the standpoint of general optical theory, and (ii.) on the hypothesis of molecules imbedded in a dielectric. Both methods lead to equivalent results. The formulæ arrived at, after making certain assumptions for the sake of simplicity, are

$$n^2(1-\kappa^2) = \epsilon_0 + \frac{\epsilon_\infty - \epsilon_0}{1+\left(\frac{a'}{\mathrm{T}}\right)^2}$$

$$2n^2\kappa = \frac{\epsilon_\infty - \epsilon_0}{1+\left(\frac{a'}{\mathrm{T}}\right)^2}\cdot\frac{a'}{\mathrm{T}},$$

where n is the coefficient of refraction of the substance, κ its index of absorption, T the period of the incident rays, ϵ_0, ϵ_∞, and a' three constants characteristic of the substance examined.

The concluding part of the paper contains a comparison of theory with experiment for various alcohols, organic acids, glycerine, and creosote. G. B. M.

795. *Effect of Wave-form on Capacity and Inductance Measurements.* **H. F. Weber.** (Annal. Phys. Chem. 63. 1. pp. 366–375, 1897.)—One of the simplest methods of measuring capacity and inductance is that involving the use of alternating currents. In using this method it has been customary to assume that the potential difference and current-waves are of the simple sine form. In most cases, however, this assumption is not correct. It is, then, important to determine in how far the measurement may still be considered valid. The author shows that, if the formula

$$C = I/pV$$

(where C = capacity, I = current, $p = 2\pi \times$ frequency,* and V = potential difference) be used irrespective of the wave-form, then the correct value of the capacity is obtained by multiplying the above result by the correcting factor

$$f = \sqrt{\frac{1+\frac{P_3^2}{P_1^2}+\frac{P_5^2}{P_1^2}+\dots}{1+9\frac{P_3^2}{P_1^2}+25\frac{P_5^2}{P_1^2}+\dots}},$$

where $P_1, P_3, P_5, \dots$ stand for the amplitudes of the simple harmonic terms into which the E.M.F. wave may be analysed (only *odd* harmonics being present). From this it is evident that a comparatively slight departure from the sine form may give rise to serious error, while with considerable distortion the error may be very large. By way of example, the E.M.F. wave of a Ganz machine ($P_1=100$, $P_3=38{\cdot}4$, $P_5=15{\cdot}6$) is quoted as giving a value of $f=0{\cdot}632$.

Dealing next with inductance measurements, the author shows that the value calculated from the formula $L=V/pI$ (the resistance assumed to be negligible) must be multiplied by the correcting factor

$$\sqrt{\frac{1+\frac{1}{9}\frac{P_3^2}{P_1^2}+\frac{1}{25}\frac{P_5^2}{P_1^2}+\dots}{1+\frac{P_3^2}{P_1^2}+\frac{P_5^2}{P_1^2}+\dots}}$$

in order to obtain the true value. This expression shows that, even with considerable deviations from the sine form, the error due to the use of the simpler formula will never be very great (the Ganz machine gives a correcting factor of 0·932). Hence the alternating-current method is more suitable for the measurement of inductances than of capacities.

The paper concludes with a criticism of a method suggested by

Stefan for ascertaining roughly whether the E.M.F. wave of an alternator departs widely from the sine form; and the method is shown to be useless, the only reliable plan being to actually determine the shape of the wave. A. H.

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796. *Graphical Study of Alternate Currents.* **C. E. Guye.** (Écl. Électr. 14. pp. 503–508, 1898.) (See Abstract 524.)—The methods of representing a sine function by means of rectangular and polar coordinates are considered; then follow the rules for the composition of alternating vectors. The graphical representation of successive differential coefficients of a sine function is next explained. In the case of any periodic function, the equivalent sine function (*i. e.* one having the same R.M.S. value) may be used to replace it. The cosine of the angle of phase-difference between any two periodic functions is defined as the ratio of their mean product to the product of their R.M.S. values. Although, so far as power is concerned, the use of equivalent sine functions furnishes correct results, yet in other instances—as, *e. g.*, the balancing of an inductance by a capacity, the determination of the greatest stress in the insulating material, or the hysteretic loss in transformers—the use of the equivalent sine function cannot be adopted. This leads to the introduction of the *form factor* of a periodic function.

The article concludes with a consideration of the composition of sine functions of different periods. A. H.

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797. *Measurement of Phase-difference.* **A. G. Rossi.** (Écl. Électr. 15. pp. 133–140, 1898.)—The method described depends on the production of a rotating magnetic field by means of the two currents whose phase-difference is to be determined. It is primarily applicable only to currents obeying the sine law. If two similar coils traversed by sine currents of equal amplitude and having a phase-difference ϕ be inclined at an angle $\pi-\phi$, then the field at the common centre of the coils will be a rotating field of constant intensity. If the amplitudes of the currents are not equal, a rotating field may still be produced, by sending the larger current through two coils—each of half the number of turns contained in the coil carrying the other current—inclined at such an angle as to render the resultant alternating field equal in amplitude to that produced by the other current. This artifice may obviously be applied to both coils at the same time, each being replaced by two half-coils inclined at a certain angle. The angles may be so chosen as to make two of the half-coils belonging to different sets co-planar. We then get the arrangement shown in Fig. 1, where A and A′ denote the planes of one set of coils, B and B′ denoting the other. It may be shown that the phase-difference is $\frac{1}{2}(\psi_1+\psi_2)$ when the resultant field is a rotating one. In order to determine this latter point, a fluorescent screen is used

on which impinges a pencil of kathode rays. The angles ψ_1 and ψ_2 are then adjusted until the orbit of the luminous patch on the screen becomes circular. The actual arrangement used by the author is sketched in Fig. 2, and consists of two hinged circular conductors. The method may be extended to currents of wave-shapes not very different from a sine wave by adjusting the positions of the hinged portions of the conductors until a figure is traced out on the screen which exhibits symmetry about two mutually perpendicular diameters. A. H.

Fig. 1.

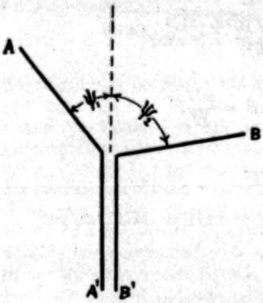
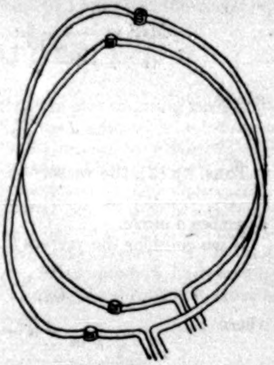


Fig. 2.



[*To be continued.*]

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798. *The Application of Imaginary Quantities to Transformer Equations.* **J. B. Pomey.** (Écl. Électr. 15. pp. 16–18, 1898.)—If $i=\sqrt{-1}$, then the locus

$$\rho=\frac{m+nx}{m'+n'x} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

is a circle, when m, m', n, n' are given imaginary quantities, and x is a variable parameter.

The locus

$$\rho=\frac{m+ne^{it}}{m'+n'e^{it}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

is also a circle, t being a variable parameter.

The transformer equations may be written

$$\left.\begin{aligned}(R+pLi)I+pMiI' &= E,\\ pMiI+(R'+pL'i)I' &= 0,\end{aligned}\right\}, \quad . \quad . \quad . \quad . \quad (3)$$

where R, L, I are the resistance, self-induction, and current in the primary circuit; R′, L′, I′ corresponding quantities for the secondary circuit; E the primary impressed potential difference; and $p=2\pi n$, n being the frequency of the currents.

From equations (3) we get

$$p\mathrm{M}i\mathrm{I}' = \frac{\mathrm{E}}{1+\dfrac{\sqrt{\mathrm{R}^2+p^2\mathrm{L}^2}\sqrt{\mathrm{R}'^2+p^2\mathrm{L}'^2}}{p^2\mathrm{M}^2}\cdot\epsilon^{i(\alpha+\beta)}},$$

where

$$\tan\alpha=\frac{p\mathrm{L}}{\mathrm{R}},\quad \tan\beta=\frac{p\mathrm{L}'}{\mathrm{R}'}.$$

Thus, by (2), the vector

$$\rho = p\mathrm{M}i\mathrm{I}'$$

describes a circle.

If we consider the vectors OA=E and OB=pMiI′, we get

$$\frac{\mathrm{BA}}{\mathrm{OB}} = k\epsilon^{(\alpha+\beta)i},$$

where

$$k = \frac{\sqrt{\mathrm{R}^2+p^2\mathrm{L}^2}\sqrt{\mathrm{R}'^2+p^2\mathrm{L}'^2}}{p^2\mathrm{M}^2},$$

which shows that the ratio of the lengths of BA and OB is equal to k, and that the angle between the two vectors is $\alpha+\beta-\pi$.

The point B is, if the vector OA is given, the intersection of the following circles:—First, the locus of points such that the ratio of their distances to the points O and A equals k; and, second, the locus of points at which OA subtends an angle $\alpha+\beta-\pi$.

W. G. R.

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799. *Theory of Alternating Currents.* **W. G. Rhodes.** (Roy. Soc. Proc. 62. pp. 348–349, 1898.)—This paper is divided into two parts. Part I. deals with the determination of equivalent impedances of multiple circuits and generally with the complete investigation of complicated arrangements of mutually dependent circuits. The method adopted depends upon the fact that if a simple harmonic function is differentiated twice in succession, the result is proportional to the original function.

Part II. considers the effect of harmonics in alternating current circuits. It is shown that any periodic E.M.F.'s and corresponding currents can always be represented by simple sine curves having the same root mean square values, and suitable phase positions depending only on the time constants of the circuits and on the periodicities of the harmonics present. AUTHOR.

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800. *Electrodynamometer in Shunt.* **M. Wien.** (Annal. Phys. Chem. 63. 1. pp. 390–394, 1897.)—Let the resistances and self-inductions of the shunt and dynamometer circuits be respectively

r_1, L_1 and r_2, L_2; the frequency n, the dynamometer constant k, and its deflection d.

The author deduces a general value of the dynamometer deflection for any current in terms of the amplitudes of its sine components. This depends on the frequency and is complex, reducing itself, however, in the particular case when $L:L=r:r$ to the formula, for sine currents,

$$[\text{Effective current}]^2 = dk^2\frac{[r_1+r_2]^2}{r_1^2}.$$

To obtain this condition the dynamometer and shunting resistance are joined up in a Wheatstone Bridge with adjustable resistances r_3 and r_4. r_1 and r_3/r_4 are varied until balance is obtained, employing alternating currents and telephone. Then $r_1 : r_2 = L_1 : L_2 = r_3 : r_4$, giving at once the required condition and the shunt ratio. By providing a dynamometer with special shunting-coils satisfying these conditions, an enormous range may be given to the instrument. In the case of an approximately sine current, if $L_1=0$ and $n^2L_2^2$ is large compared with r_2^2, a condition satisfied by inserting inductive coils in the dynamometer circuit, the divergence from a true sine current becomes negligible, and

$$\text{Effective current} = \frac{k}{r_1}\cdot\sqrt{d\{[r_1+r_2]^2+n^2L_2^2\}}.$$

A dynamometer employed in shunt must be free from iron and large metal pieces, so that its inductance is independent of the frequency. G. H. Ba.

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801. *Lecture-room Galvanometer.* **R. W. Quick.** (Amer. Electn. 10. p. 166, 1898.)—The paper describes a lecture-room galvanometer which, while having a suspended magnetic system, does not require the special lantern necessary with a mirror-galvanometer, but can be used in the ordinary projection lantern, provided this has a vertical attachment. The coil has a horizontal axis in which an aluminium pointer is suspended. Below this is a horizontal glass plate with a scale of tangents, through which the light is transmitted vertically and then reflected. G. H. Ba.

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802. *Quadrant Electrometer.* **J. Elster** and **E. Geitel.** (Annal. Phys. Chem. 64. 4. pp. 680–684, 1898.)—The drying apparatus attached to the quadrant electrometer designed by the authors is a piece of sodium attached to a wire which is mounted in a side tube off the chamber containing the quadrants. The damping liquid is petroleum, contained in a vessel with a ground-glass edge which presses against the rubber-padded inner edge of the main chamber. It is both air-tight and easily removed. The improved electrometer has a very constant zero. E. E. F.

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803. *Electric Arc.* **A. Hess.** (Écl. Électr. 15. pp. 49–51, 1898.)—This article gives an account of recent research on the electric arc. C. K. F.

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804. *Annular Standard of Inductance.* **I. Fröhlich.** (Annal. Phys. Chem. 63. 1. pp. 142–158, 1897.)—Describes a shape of standard which allows of an exact geometrical calculation of its value. It consists of a ring of Carrara marble of rectangular section, wound with a single layer of a fine insulated copper wire in 2738 turns. The ring is divided into two halves, each of which, being of a semicircular shape, can be connected independently. The shape is accurately measured by the cathetometer. The self-induction of such a ring is given by the equation

$$L=2n^2h\log_e\frac{r_2}{r_1}-2n^2h\,.\,0{\cdot}28721\left[\rho\left(\frac{1}{r_1}+\frac{1}{r_2}\right)+\frac{2\rho}{h}\log_e\left(\frac{r_2}{r_1}\right)\right],$$

where r_1, r_2 are the internal and external diameters of the ring, h its thickness, ρ the radius of the wire, and n the number of turns. The value experimentally found does not differ from the calculated value by more than ½ per cent. E. E. F.

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805. *Standard Resistances of the Reichsanstalt.* **W. Jaeger** and **K. Kahle.** (Annal. Phys. Chem. 64. 3. pp. 456–485, 1898.)—This paper deals fully with the construction and calibration of the Reichsanstalt standards. It describes the geometrical measurement of the tubes containing the mercury standards, the weighing of the mercury contained in them, the calculation of the resistance, and allowance for the extension resistance where the narrow standard tubes join the terminal bulbs. Further, it describes the method of copying the standard tubes and comparing them among each other and with manganin-wire resistances. When filled in a vacuum, the resistances of several successive fillings need not differ by more than a few 100,000ths of an ohm, and the secular change in four or five years is of the same order, as is also the secular change of the manganin resistances. E. E. F.

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806. *Electrical Alloys.* **R. Appleyard.** (Elect. Rev. 42. pp. 536–537, 1898.)—This is the first of two articles on alloys used for various electrical purposes. It is almost entirely a translation from Vol. ii. of the 'Wissensch. Abhandl. d. P. T. Reichsanst.' German silver, nickel, and "patent nickel" are examined as to their *chemical constitution*, *specific resistance*, and *thermo-electric power against copper*. The effect of *rolling*, as regards change of resistance, is also tabulated for various alloys. If the diameter of the roller is 40 times that of the wire, only a very small increase in the resistance of "patent nickel" is observed; with German

silver the increase is about four times greater. If rollers 10 times the diameter of the wire are used, both alloys show a change of resistance of about four times the above amount; this is attributed partly to stretch and partly to hardening. The *quasi-permanent changes of resistance due to heating* are examined by submitting specimen resistance-coils for several hours in thermostats at 40° C., 100° C., and 150° C. successively, and then again at 100°, measuring the resistance before and after each heating. It is thus proved (1) that the specific resistance of German silver and nickelin can be made approximately constant by prolonged heating at 150° C., and (2) that the specific resistance of patent nickel becomes constant under the same treatment, so that it does not undergo subsequent change even when heated to 100° C. Reference is also made to similar work done by Klemenčič. AUTHOR.

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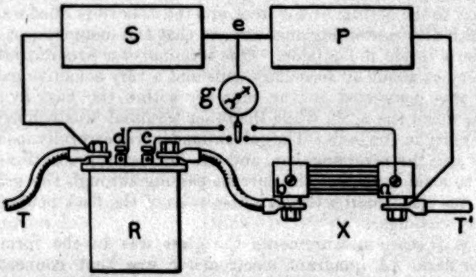
807. *Comparison of very Small Resistances.* **S. Sheldon.** (Elect. World, 31. p. 296, 1898.)—The unknown resistance X (see figure) which may be assumed to be supplied with branch potential points *a*, *b*, is connected by heavy conductors in series with a standard branch resistance R, of the Reichsanstalt pattern, having potential points *c*, *d*. From the two free terminals, TT′, of these resistances are shunted two 10,000 ohm resistance-boxes S, P, adjusted to the same normal temperature and wound with wire of the same or negligible temperature coefficient and connected in series. From the point of connection *e*, between the two boxes, is connected one terminal *g* of a sensitive d'Arsonval galvanometer, the other terminal being successively connected with the potential points *a*, *b*, *c*, and *d*. At first all the plugs are removed from the box S, and all are in place in the box P. After connecting T and T′ with a source of heavy current, plugs are transferred from one box to the corresponding holes in the other box, keeping the total resistance in the two boxes constant until no deflection is observed in the galvanometer. This operation is repeated for each of the potential points *a*, *b*, *c*, *d*. Representing the resistances in the box S corresponding to each of these balances by S_a, S_b, S_c, and S_d



respectively, we have for the unknown resistance the expression

$$X=\frac{S_a-S_b}{S_c-S_d}\cdot R.$$

W. G. R.

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808. *Electrical Properties of Glass.* **A. Gray** and **J. J. Dobbie.** (Roy Soc. Proc. 63. pp. 38–44, 1898.)—The experiments described are the first instalment of work undertaken by the authors with a view to determine the circumstances which affect the conductivity and specific inductive capacity of glass. Previous experimenters have shown that potash and soda-lime glasses have a higher conductivity than flint glasses. It seemed desirable to ascertain whether by increasing the amount of lead-oxide and diminishing the amount of soda, the conductivity would go on diminishing. From manufacturers in London and Jena various specimens of glass were obtained, all richer in lead than those formerly available, and, further, in some cases practically free from soda. Specimens of glass used for thermometers and a barium crown glass were also tested. The method of determining the *conductivity* was the same as that adopted in previous experiments described in Proc. Roy. Soc. No. 231, 1884. When the glass admitted of it, the specimen was used in the form of a flask: this was filled up with mercury to the bottom of the stem, and the flask thus filled was sunk in a bath also containing mercury, so that the mercury was at the same level inside and outside. One terminal of a circuit containing a battery of about 30 secondary cells and a very sensitive galvanometer was connected to the mercury within the flask by a wire passing down the neck, while the other terminal was connected to the mercury in the bath. The galvanometer was carefully insulated, as was also the reversing key, and all necessary precautions were taken to make sure that the current passing through the galvanometer was that passing through the walls of the flask between the mercury coatings.

In the *capacity* measurements the glass was in the form of a plate or flask. A quadrant electrometer was kept connected to the plates of one of Lord Kelvin's air-leydens. This was charged to a potential difference of about 24 volts by means of 12 secondary cells. After the battery had been removed, a reading was taken of the electrometer deflection, and then the specimen was connected for a very short time as a condenser in parallel with the leyden. The connection was made by means of a myograph pendulum, which, when freed, swung over a considerable arc to a catch which prevented it from returning. The arrangement was such that the interval of time during which the connection between the two condensers endured was reckoned as at most about 1/30,000 of a second.

The plates were originally rather over ¼ in. thick, and after some observations of capacity had been made and it had appeared that their resistance was too great to be measurable, the thickness was reduced by cutting and grinding to about 0·24 cm. After polishing and cleaning, they were covered on both sides with a dense and thoroughly adherent coating of silver. This was cut away for a space of about ½ in. round the edges; care being taken to remove every trace of silver and to make the edge thoroughly clean. The glass plate was laid with one coating of silver resting on a plate of copper at the bottom of an iron bath. Another plate of copper was laid on the upper coating of silver and kept down with a weight, and the connections of the battery circuit described above were made with the copper plates. The iron bath was placed within a larger bath partly filled with sand, so that the temperature could be raised by heating the outer bath from below. The results of the experiments are given in a table, which states the density, specific resistance, specific inductive capacity, and chemical composition of each specimen experimented on. The following extract from the authors' table gives some particulars of the results they obtained with the four specimens of glass they used:—

Description of glass.	Density.	Specific Resist. (ohms).	Sp. ind. cap.
Lead-potash glass (Powell, London).	3·495	Too high to measure: above $18{,}000 \times 10^{10}$ at 130° C.	7·966 at 15° C. 7·630 at 120° C.
Lead-potash glass (Schott & Co., Jena).	3·591	Too high to measure: above $35{,}000 \times 10^{10}$ at all temps. to 135° C.	7·991 at 14° C.
Barium glass (Schott & Co., Jena).	3·565	Too high to measure; above $59{,}000 \times 10^{10}$ at all temps. to 140° C.	8·5. No variation with temperature. No absorption effect.
Zinc-soda "Jena glass" (Schott & Co.).	3·493	$596{\cdot}5 \times 10^{10}$ at 43° C. $0{\cdot}200 \times 10^{10}$ at 140° C.	7·54 at 15° C. Conduction too great at high temps.

The resistance was taken after 5 mins. electrification in each case. The "Jena glass" (No. 4 above), both in resistance and capacity experiments, showed very considerable effects of dielectric polarisation, which took a long time to disappear. The same was true of Powell's lead glass. On the other hand, the barium glass in the capacity experiments showed little or no sign of polarisation effects. This glass has a very high resistance, and in this respect behaves more like lead than lime glasses, which have usually low resistance. The "Jena glass" has a low resistance, as was to be anticipated from its high percentage of soda and complex composition. Experiment points to the conclusion that a glass which approaches in composition to a definite chemical compound has a high resistance. J. J. S.

809. *Electrical Resistance of Metals.* **C. Liebenow.** (Zeitschr. Elektrochem. 4. pp. 201–211, and pp. 217–227, 1897.)—If a large number of thin alternate plates of two different metals are pressed together and a current passed through the pile, heat will be absorbed, say, when the current passes from metal M_1 to metal M_2 and evolved when it passes from M_2 to M_1. Owing to the differences of temperature thus produced at the junctions a counter-E.M.F. will be developed, equivalent to an apparent increase of resistance. Assuming that the plates are so thin that the differences of temperature are always small, this E.M.F. is found to be represented by the equation

$$E=rc,$$

where c is the current and

$$r=\frac{n(1-n)}{a(1-n)+bn}\frac{l}{q}f(T), \quad . \quad . \quad . \quad . \quad . \quad (1)$$

n being the part of the total length consisting of the one metal, $(1-n)$ the corresponding fraction for the other metal, l and q the length and cross-section of the pile, $f(T)$ a function of the temperature, and a and b the specific conductivities of the two metals for heat. This equation is true whether the plates are of equal thickness or not. The author considers that a metal containing dissimilar molecules would be equivalent to such a pile, and its resistance would be equal to the sum of the resistances of the metals together with an extra part due to the thermo-E.M.F. above considered.

Calling A_0 the sum of the resistances of the pure components, B_0 the extra resistance, and C_0 the specific resistance of the alloy, all at 0°, we have

$$C_0=A_0+B_0, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

or at t°

$$C_0(1+\gamma t)=A_0(1+\alpha t)+B_0(1+\beta t). \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

For pure metals $\alpha=0{\cdot}004$ approximately, and for a cube of unit side

$$B_0=\frac{n(1-n)}{a(1-n)+bn}f(T_0),$$

where a and b are now the internal heat conductivities of the molecules. B_0 is a maximum for $n=1/1+\sqrt{\frac{b}{a}}$. The positive root alone gives possible values for n (viz. between 0 and 1), so that there is only one such maximum.

From (2) and (3),

$$\gamma=\frac{A_0\alpha+B_0\beta}{C_0}. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

According to Matthiessen the conductivities of the alloys of certain metals are the mean of those of the components, the quantities of the latter being calculated as volumes. In these cases $B_0=0$, and therefore $\gamma=\alpha$. That is, the resistances of the alloys have the same temperature coefficient as pure metals, which is in accordance with the facts. Another group of alloys has smaller conductivity than the mean of the conductivities of the components, and in this case Matthiessen finds the following relation to hold:

$$A_0-A_0(1+100\alpha)=C_0-C_0(1+100\gamma),$$

from which

$$\gamma=A_0\alpha/C_0. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

Comparing this with (4) it follows that in this class $\beta=0$, which would be true if $f(T)=\text{const}$. Making this assumption, it is shown that equation (2) is capable of accurately representing Matthiessen's results with alloys of gold with copper or silver; the values of a, b, and $f(T)$ are calculated from the observations. In the case of some alloys of nickel and copper studied by Feussner, which have a negative temperature coefficient, β must have a negative value.

If the two metals (M_1 and M_2) combine to form a compound, there will be a series of alloys containing molecules of M_1 and of the compound, then the pure compound, and finally a series containing compound molecules and molecules of M_2. In the pure compound the thermo-E.M.F. must disappear, since the molecules are all identical, and the temperature coefficient should be equal to that of the pure metals; for the alloys containing excess of one or other of the component metals the temperature coefficients are smaller. The curve representing the connection of temperature coefficient and composition has therefore a maximum corresponding to the composition of the compound. Similar considerations hold for the resistance. This, the author considers, is the first reliable method proposed for determining whether an alloy is a true compound or merely a mixture. Zinc and copper appear to form the compound CuZn. In pure metals the molecules move with different velocities, that is they have different temperatures. Owing to these temperature differences a current passing through the metal gives rise to an opposing E.M.F. in the same way as in the thermopile, except that groups of identical molecules at different temperatures take the place of the heterogeneous molecules. The mathematical treatment is practically the same. The paper concludes with some remarks on thermo-electromotive forces, and on the interesting properties of true compounds of the metals, for which the original must be consulted. T. E.

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810. *Thermo-electric Currents.* **Bakhmetieff, Christodulus,** and **Georgieff.** (Écl. Électr. 15. pp. 81–85, 1898; Journ. Soc. Phys. Chim. Russe, 29. p. 14.)—The authors melt tin in a porcelain capsule into which are plunged wires connected to a galvanometer; the capsule is placed in a chamber which can be surrounded at pleasure by ice. The authors find that there is an E.M.F. in the

circuit which remains practically constant as the tin solidifies and then diminishes. This E.M.F. is greater the lower the temperature of the chamber. When the chamber is not surrounded by ice the temperature of the solidifying tin is 220° C., the average of the surrounding chamber during the whole time of solidification 85° C., and the E.M.F. 49·9 microvolts. With the chamber surrounded by ice the figures are 218°·5 C., 54°·5 C., and 103·2 microvolts. The authors have also experimented with a tin-cadmium alloy. E. C. R.

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811. *Change in the Zinc Sulphate in Clark Cells.* **W. Jaeger.** (Annal. Phys. Chem. 63. 1. pp. 354–365, 1897.)—Ordinary crystalline zinc sulphate which is represented by the formula $ZnSO_4 + 7H_2O$, changes at 39° C. to $ZnSO_4 + 6H_2O$, giving up a molecule of water. These two different forms possess different solubilities, and Clark cells made up with the two forms would have different electromotive forces and different temperature coefficients. It thus follows that at 39° C. there is a sharp bend in the temperature-coefficient curve of a Clark cell. The present author has succeeded in tracing that part of the curve above 39°, which corresponds to $ZnSO_4 + 6H_2O$, down from 39° to 0° C. By repeated warming to 50° or 60° C. and slow cooling, the sulphate did not change back again into the ordinary form, so that the electromotive force due to the anomalous sulphate was measured at all temperatures down to 0° C. The electromotive force of such a cell at about 15° C. is less than that of the ordinary Clark cell by ·7/1000. On dropping a crystal of normal sulphate into the cell, the transformation to the normal form takes place very quickly with a return to the normal electromotive force. The paper, which emanates from the Reichsanstalt, contains a number of tables of results and diagrams showing the difference between the appearances of the cells in the two states, the ordinary and the anomalous. J. B. H.

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812. *Temperature Measurements in Electrolytic Cells.* **F. Richarz** and **W. Ziegler.** (Annal. Phys. Chem. 63. 1. pp. 261–267, 1897.)—It was shown several years ago by one of the authors that the temperature of a small electrolytic cell surrounded with ice does not approximate to 0° throughout, as is often tacitly assumed, but in the neighbourhood of the electrodes, especially when the latter are relatively small, rises enormously as the current is increased, and eventually, near the boiling-point of the electrolyte, gives rise to a phenomenon analogous to Leidenfrost's spheroidal state. The results of a series of exact experiments on the subject are now given. The experimental cell consists of a test-tube 7 cm. × 24 mm. diam., which is surrounded with crushed ice and filled with 20 °/₀ sulphuric or nitric acid as electrolyte. One electrode is a cylinder of platinum-foil fitting within the tube, whilst the other, at the surface of which the temperature is to be

measured, is a platinum wire passing down the axis of the tube. Attached to this wire but insulated from it by a glass capillary sleeve 3 mm. long, is a platinum-platino-iridium couple. The strength of the current being raised by regular increments of 0·5 ampere, the temperature is read off at each stage as soon as it is constant; it is found to rise steadily as the current increases, until, at a few degrees below the boiling-point of the electrolyte, the spheroidal phenomenon sets in. The distribution of temperature in the cell is mathematically discussed, and the experimental results are found to agree with the calculated as closely as can be expected, seeing the uncertainty of some of the data involved. It is pointed out that the heating at the electrode notably diminishes the resistance of the cell, and that determinations of E.M.F. of polarisation in which the resistance is assumed constant may consequently be seriously affected: an error of as much as 2 volts may in fact be thus introduced. J. W.

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813. *Thermo-electric Batteries and the Jacques Cell.* **W. A. Anthony.** (Amer. Electn. 9. pp. 431–432, 1897.)—In continuation of the discussion (see Abstract No. 658) Anthony states that in his opinion some of the oxygen goes into solution or in some other way comes into electrical connection with the iron electrode, and combines with the positive ion in strict accordance with Faraday's law. In support of this statement, he has found that more oxygen bubbles through on open circuit than on closed circuit, and the current falls to a low value *immediately* on stopping the flow of gas. The same sort of thing occurs in the Grove gas battery, and there is no difficulty in regarding the oxygen as a depolariser, just as in two-fluid cells, although not a compound. The source of energy omitted by Reed in calculating the E.M.F. is the union of oxygen with the positive ion. The reaction is

Iron.	Before. $2O+3KHO+C$ After. $\left.\begin{matrix}KHO\\H_2O\end{matrix}\right\}+K_2CO_3$	Carbon.

C. J. Reed (Amer. Electn. 9. pp. 432–433, 1897) denies that the oxygen which combines with the positive ion does so in accordance with Faraday's law. It is simply a case of combustion. As the oxygen and the oxidised body are not connected by any electric conductor other than the electrolyte, the reaction cannot evolve electrical energy. The only possible sources of energy are (1) the energy of carbon oxidised within the cell, (2) the heat energy evolved within the cell by the oxidation of reduced ions, (3) the heat energy absorbed from without. The reaction suggested by Anthony, viz.:

$$2O+2KOH+C=H_2O+K_2CO_3,$$

does not take place, the formation of carbonate being incidental and subsequent to that of CO_2.

Elihu Thomson (Amer. Electn. 9. p. 476, 1897) states some facts with regard to the Jacques cell. CO_2 does not escape when the cell is in action, but produces alkaline carbonates from the hydrate, oxygen, and carbon. An equivalent supply of hydrate is therefore required. The formation of carbonate goes on whether the circuit be opened or closed, but stops when the oxygen is stopped, indicating direct combination of oxygen with hydrate or carbon. The Jacques cell probably resembles a copper-sulphuric-acid-carbon cell to which an oxidising agent is added. Copper sulphate is formed whether the circuit is closed or open, but the cell is nevertheless capable of giving a current. In fact a great deal of local action is taking place. Now replace the copper by carbon, the sulphuric acid by caustic soda, and the carbon by iron: we then have the Jacques cell. The energy may all appear as heat within the cell, or partly as electric energy in an external circuit.

W. A. Anthony (Amer. Electn. 9. pp. 476–477, 1897) complains that Reed does not fairly interpret his statements. He agrees with Thomson's views. The fact that carbonate is formed at nearly the same rate whether the circuit is open or closed, shows that an enormous amount of local action takes place. This is certain to be so if the stream of oxygen is allowed to flow against the carbon. To avoid local action, the oxygen should be carefully kept away from the carbon just as a depolariser in two-fluid cells is kept away from the zinc. If this were done, the carbonate formed would probably be found to be nearly the equivalent of the current. His own experiments show that much more oxygen is consumed on closed than on open circuit when it is kept away from the carbon.

W. Ostwald (Amer. Electn. 10. pp. 16–17, 1898) compares the Jacques cell to a Lalande cell. The latter becomes exhausted as soon as the copper oxide is all reduced, but might be again rendered active by blowing a stream of oxygen on to the copper. In the Jacques cell the place of the copper oxide is taken by ferric oxide or sodium ferrate. The only active substance is the absorbed oxygen, the energy set free by the union of the oxygen with the copper or the iron being lost as far as the electrical process is concerned. There is no way known as yet for preventing this loss, or of directly utilising the chemical potential of free oxygen on a commercial scale. The difficulty in obtaining electricity from coal rests, on this account, more with the oxygen than with the coal. In the Jacques cell the oxygen is only required at the kathode: any that reaches the coal and burns it directly only gives rise to local action. The formation of ferrate may be neglected in any calculation of E.M.F. because it may be assumed that just as much ferrate is re-formed by the oxygen as is decomposed by the current. Consequently the only reaction to be considered is

$$2NaOH + C + O_2 = Na_2CO_3 + H_2O.$$

The E.M.F. equivalent to this is 2·66 volts, assuming the heat of reaction to be the same as at ordinary temperatures.

C. J. Reed (Amer. Electn. 10. pp. 17–20, 1898) remarks that he has apparently given Jacques credit for more than he deserves. It has been stated that the greater part of the CO_2 escapes without combining with the caustic soda. But from the statements of Thomson and Anthony it now appears that an equivalent of caustic soda is required. The total efficiency of 32 °/₀ as given by Jacques therefore drops to 24 °/₀; and if two-thirds of the energy is required to operate the air-pump, as stated by J. H. Helweg, jun., this figure falls to 8 °/₀. Coming to cost, the raw material for the Jacques battery will cost at least thirty-four times that for a good steam-engine, and the residue will weigh ten or twelve times that from the boiler. The whole question of the theory of the cell depends upon the function of the oxygen forced into it. There is no possibility of galvanic action without the energy evolved by oxidation. That the action is thermo-electric is sufficiently supported by the fact that if iron is substituted for the carbon, a still higher E.M.F. results, without a stream of air, both electrodes being iron in that case. The idea that free oxygen can act as a depolariser is a mistake; it must be in combination. Free oxygen with a platinum electrode acts as a depolariser because, as Berthelot pointed out, the platinum combines with the oxygen. That is not the case with carbon. He agrees with Ostwald that the function of the oxygen is to reoxidise the reduced iron, and that the energy of this reaction is lost as far as any electrical process is concerned. Why the reduction of the oxide should be omitted by Ostwald in calculating the E.M.F. is not clear. It should be included just as well as the reduction of copper oxide in the Lalande cell. The continuous renewal of the ferrate is no reason why this part of the reaction should be omitted. In the calculation of the E.M.F. as given by Ostwald, the result should be 1·33 volts instead of 2·66, carbon being tetrad. If the reduction of ferric oxide is taken into account in calculating the E.M.F., the result is negative, showing that such a reaction cannot be galvanic. The correctness of these views is shown by an experiment carried out by the author with a silver crucible. Metallic sodium was given off from the walls of the crucible. The liberation of sodium increased continuously after alloying with the silver, notwithstanding the fact that a strong blast of air was forced through the cell. Twenty minutes after closing the circuit the E.M.F. had fallen to zero and reversed, and in thirty minutes the explosions were so violent that the experiment had to be stopped. The crucible was found to have formed a porous alloy with the sodium.

W. A. Anthony (Amer. Electn. 10. pp. 63–64, 1898) disputes Reed's statements with regard to the depolarising action of oxygen. It is not an accepted fact that oxygen combines with a platinum electrode. The view generally held is that it is condensed upon the surface. Similar results are obtainable with carbon. An inert gas, or vibration, does not have the same effect. With regard to the action of two iron electrodes at different temperatures in caustic soda, it is questionable if they would, as stated by Reed, indefinitely maintain an E.M.F. of 1·2 volts so long as the temperature is maintained.

J. Thomsen (Amer. Electn. 10. p. 64, 1898) believes that the action is galvanic. Taking the equation,

$$C+2NaOH+O_2=Na_2CO_3+H_2O,$$

the heat corresponding to this amounts to 133,440 calories. To determine how much of this is available, three possibilities must be considered:—(1) The oxygen may combine direct with the carbon; (2) the oxygen may form oxide of iron which is again reduced by the current; (3) the oxygen may be occluded by the iron or caustic soda before the reaction takes place. No cases are known in support of the first. The second cannot be adopted, as there would be no resulting evolution of heat on the total reaction. It is, therefore, reasonable to suppose that the oxygen is occluded. Ramsay, Mond, and Shields have found the heat of occlusion by platinum to be 17,600 calories. Assuming that of iron to be about the same, the heat of reaction amounts to 133,440 − 35,200 calories, and the E.M.F. to 1·07 volts.

C. J. Reed (Amer. Electn. 10. pp. 109–110, 1898) remarks that, according to Thomsen's statements, the action of the Jacques cell is thermo-electric unless oxygen is occluded by the iron. There is, however, no evidence in support of the view that iron at 500° C. will occlude oxygen. He also criticises the experiments of Anthony upon the depolarising power of oxygen.

It is not possible to refer in an abstract to all the various points raised in this discussion. W. R. C.

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814. *Disturbing Action of Electric Currents on Magnetometers.* **C. H. Davis.** (Écl. Électr. 15. pp. 27–28, 1898; Terrestrial Magnetism, 11. p. 125, 1897.)—The photographic records of the magnetic elements at the Washington naval observatory are affected to a marked degree by the working of an electric tramway passing within about 425 m. of the observatory. The disturbance amounts to an increase of 15×10^{-6} dyne in the value of the vertical component when a single car is running, and reaches 300×10^{-6} dyne at times of heavy traffic; a short circuit caused a diminution of 1500×10^{-6} dyne, lasting for 1½ hours. The rails were rebonded, and joined to the neighbouring water- and gas-pipes, without effect. Another tramway, 1200 m. distant, produces appreciable disturbances, as well as an arc-lamp circuit with earthed return in the town. The magnetic observations at the Toronto observatory, situated within 215 m. of an electric tramway, have had to be discontinued. The least distance at which the effect of the currents becomes negligible is 2 miles: it is suggested that earthed returns should be forbidden in the vicinity of magnetic observatories. A. H. A.

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815. *Magnetisation of Cylinders.* **L. Holborn.** (Berlin. Akad. Sitzber. 10. pp. 159–168, 1898.)—The author investigates the situation of the poles in a magnetised iron cylinder under various circumstances. The apparatus consists of two coils, one of which is very short, so that all the lines of force pass through its open ends without loss, while the other is so long that all the lines of force penetrate the turns of the coil. The effective length of the magnet is then obtained from the induction impulses in the two coils produced by the magnetisation of the cylinder. The results for total magnetisation show that the distance between the two poles of a cylindrical magnet 15 cm. long varies between 10·8 and 13·7 cm., or between 0·72 and 0·91 per cent. of the total length. As the field increases in force the distance between the poles decreases at first. The minimum coincides with the maximum of magnetic susceptibility. After that is passed, the distance between the poles increases. E. E. F.

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816. *Magnetic Shielding.* **H. du Bois.** (Annal. Phys. Chem. 63. 1. pp. 348–353, 1897.)—The subject of magnetic shielding becomes every day more important owing to the great developments which are taking place in electric traction, and the consequent increase in the number of disturbing influences which affect galvanometers and other magnetic measuring instruments. The author in the present paper gives a *résumé* of the past work on the subject, and then proceeds to a theoretical investigation of the shielding produced by two concentric spherical shells and by two concentric cylindrical shells of ferromagnetic material on the internal space. An expression is deduced for the shielding effect, and the author proposes to discuss the results in a future paper.

[This paper appeared in English as the first of a series on Magnetic Shielding by the same author in the 'Electrician,' vols. 40 and 41, 1897–8.] J. B. H.

ELECTRO-CHEMISTRY AND CHEMICAL PHYSICS.

817. *Absorption of Gases by Mercury and Amalgams.* **C. Christiansen.** (Annal. Phys. Chem. 62. 4. pp. 545–568, 1897.)—This investigation was undertaken with a view to discover the cause of contact electricity, and the paper has this for its title. It contains tables giving the results of experiments on the absorption of gases by mercury and by a large number of amalgams, but most experiments were made with zinc amalgam. The mercury and amalgams were caused to flow through a fine nozzle in the bottom of one vessel, then drop through an atmosphere of the gas into another vessel. The whole apparatus was enclosed so that the same atmosphere filled both vessels, and the absorption was measured by the loss of gas in this atmosphere as registered on a manometer. Only oxygen and water-vapour seem to be absorbed. The absorption is independent of the strength of the amalgam and of the pressure of oxygen. J. B. H.

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818. *Vapour-Pressures of Dilute Solutions.* **C. Dieterici.** (Annal. Phys. Chem. 62. 4. pp. 616–643, 1897.)—The paper contains first of all a discussion of the results of experiments by different physicists on the freezing-points of dilute solutions, showing that the latest and most trustworthy results, namely those of Loomis and Ponsot, do not support Arrhenius' theory, but rather contradict it. The present experiments were undertaken to test the accuracy of the theory with regard to the vapour-pressures. The apparatus used consists of three small vessels to hold respectively water, a standard solution, and the solution whose concentration is varied. The difference in the vapour-pressures is measured by the deflection of a flexible membrane which forms part of the wall dividing another vessel into two compartments, one of the compartments being in connection with, say, the water-vessel, and the other compartment with, say, the standard solution. The difference in the vapour-pressures of the standard solution and water is obtained from this deflection, and similarly the difference between water and the other solution; the difference between the two solutions then acts as a check on the other two. The deflections of the membrane were obtained by a magnifying arrangement of mirror, telescope, and scale, and were standardised in mms. of mercury.

The results are given in tabular form for a large number of electrolytes and non-electrolytes. In all the experiments, with decrease of concentration from n to $0{\cdot}1\ n$ (where n represents 1 grm.-molecule per 1000 grms. of water), there was a decrease in the molecular vapour-pressure, whereas the dissociation theory indicates an increase. If the electrolytic conductivity therefore is to be explained on the dissociation theory, we must assume either that the variation of vapour-pressure is not to be explained on the same hypothesis, or that there is some other influence at work which makes the expected increase of pressure into a decrease. The experimental results agree qualitatively very well with those of Loomis and Ponsot on the lowering of the freezing-point. In Raoult's formula for the vapour-pressures,

$$\frac{p_w - p_s}{p_w} = c\,\frac{S}{W+S},$$

where S and W are respectively the number of molecules of solute and solvent, and c is a constant, Raoult gave the value of c for non-electrolytes as approximately unity. The present author now finds that c is not a constant, but is to some extent dependent on the nature of the solute and solvent. J. B. H.

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819. *Absorption of Gases by Liquids.* **C. Bohr.** (Annal. Phys. Chem. 62. 4. pp. 644–651, 1897.)—Up till now no simple relationship has been discovered between the amount of gas absorbed by a liquid and the temperature. In the present paper, by comparing the experimental results of Winkler, Timofejew, Bohr and Bock, Carius and Bunsen, the author has shown that the formula

$$\alpha(T \sim n) = \kappa$$

is closely satisfied between certain temperature limits. Here α is the volume of gas, measured at N.T.P., absorbed by 100 c.c. of liquid at the absolute temperature T; κ and n are constants which vary with the gases. The agreement between the numbers calculated for α from this formula and those obtained by experiment is very close up to about 50°–60° C., at which point the curve expressing αT as a function of α bends considerably away from the straight-line form which it maintains up to that point. With the gases H, N, CO, NO, and O the square root of the molecular weight is a straight-line function of the constant n, the relation being expressed by the equation

$$\sqrt{M} = n \cdot 0{\cdot}04968 \sim 6{\cdot}286.$$

J. B. H.

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820. *Diffusion Coefficients.* **W. Seitz.** (Annal. Phys. Chem. 64. 4. pp. 759–777, 1898.)—These are determined by Weber's electrolytic method. Plates of zinc are separated by a glass ring containing zinc sulphate solution. The solution is partly electrolysed, which produces a gradation of density between the plates. This gradation is subsequently obliterated by diffusion, and the progress of diffusion is observed by the diminution of the counter E.M.F. of the combination. This method reduces the time required from several days to as many hours. A difficulty lies in allowing for the irregular initial difference of potential between

plates containing a solution of zinc sulphate of uniform strength; but the author eliminates this by noting the apparent diminution of the diffusion coefficient as the experiment proceeds. The following are some of the diffusion coefficients obtained, in cm²/ days :—

Zinc sulphate 0·312 *g*/cm³......	0·1162
,, normal..........	0·2355
Zinc acetate, double normal	0·1195
Zinc formate, half normal......	0·4654
Cadmium sulphate, double normal	0·2456

Experiments with lead, silver, and tin salts yielded indecisive results. E. E. F.

821. *Optical Properties of Silicium Compounds.* **G. Abati.** (Zeitschr. phys. Chem. 25. pp. 353–364, 1898.)—The study of the refractive index and dispersive power of silicium compounds is interesting on account of their analogy with carbon compounds. Measurements made with silicium chloride, bromide, and ethyl, quartz, tridymite, opal, and methyl, ethyl, and other silicates show that the atomic refractivity of silicium not only depends upon the type of the combination, but also upon the nature of the elements entering into combination with it. In compounds of the type SiX_4 the atomic refraction rises as the following constituents are substituted:—alcoholic radicles, chlorine, bromine, and alkyl. Similar rules apply to the dispersive power. In the two propyl silicates, an interesting result is obtained. The orthosilicate shows an atomic refraction of Si amounting to 7·58, whereas the disilicate gives a value 6·04. This is probably owing to the presence of the group Si—O—Si. E. E. F.

822. *Effect of Light on the Combination of Hydrogen and Bromine.* **J. H. Kastle** and **W. A. Beatty.** (Chem. News, 77. pp. 111–112, 1898.)—It is stated that H and Br do not combine at ordinary temperatures, even in sunlight. In these experiments sealed glass bulbs containing bromine vapour and an excess of purified but undried hydrogen were heated under different conditions of light in the vapour of orthotoluidine boiling at 196° C. At this temperature, strong sunlight in 15 minutes caused about 50 per cent. of combination; on further insolation, the reaction was nearly complete. Diffused daylight effected a slow change, while in the dark there was practically no result. S. G. R.

823. *Indicators.* **John Waddell.** (Journ. Phys. Chem. 2. pp. 171–184, 1898.)—According to the dissociation theory an indicator must be a weak base or a weak acid in which one of the ions has a different colour from that of the undissociated substance (Ostwald). The presence of a liquid in which the indicator dissociates less readily than in water should cause the colour due to

the ion to be diminished. The author explains his results as follows:—Salts become dissociated in alcohol, but less than in water, still less in acetene, and very slightly, if at all, in ether, benzene, and chloroform. When dissociated, the acid ion is visible in *alkaline* solution, the basic ion in *acid* solution. Solvents will discharge or restore the colour according as they cause, or "force back," dissociation. The action is not due to precipitation, and is more marked with acetic acid and ammonia than with HCl and potash, while concentration has also an influence. The annexed table is a summary of conclusions.

Substance.	Nature.	Undissociated.	Acid ion.	Basic ion.
Fluorescein.	Acid & base.	Colourless.	Green fluorescence.	Yellowish-green colour.
Phenacetolin.	Acid & base.	Pale pink.	Bright pink.	Yellow.
Phenolphthalein.	Acid.	Colourless.	Red.	——
Paranitrophenol.	Acid.	Pale yellow.	Yellowish-green.	——
Cyanine.	Base.	Blue.	——	Colourless.
Methyl orange.	Base.	Yellow.	——	Red.
Tumeric.	Acid.	Yellow.	Red.	——
Lacmoid.	Base.	Blue.	——	Red.
Coralline.	Acid & base.	Pale yellow.	Red.	Yellow.

Some of the changes given would make striking lecture experiments.

S. G. R.

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824. *Ionisation of Alkaline Silicates.* **L. Kahlenberg** and **A. T. Lincoln.** (Journ. Phys. Chem. 2. pp. 77–90, 1898.)—Following Kohlrausch's researches (Zeit. phys. Chem. 12. p. 773, 1893), the freezing-point and conductivity of solutions of silicates of Na, K, Li, Rb, and Cs were determined. The salts were obtained by adding to dialysed silica the required amount of standard solutions of the pure hydroxides. It was first proved that solutions of sodium silicate prepared from various specimens of colloid silica were identical with one another, and with the product from the crystals of Na_2SiO_3, $9H_2O$. The freezing-points were determined by Beckmann's apparatus,—using a thermometer reading by a lens to thousandths of a degree; the conductivities by Kohlrausch's method. Great precautions were taken to exclude CO_2. Owing to gelatinisation, the strongest solution of lithium silicate that could be prepared was one thirty-second, of other silicates $\frac{1}{8}$ of a gramme-molecule per litre.

With regard to lowering of freezing-point, Na_2SiO_3 showed a value, for progressive dilutions, approaching one-fourth the molecular weight, proving that the active ions were two sodium and two hydroxyl, with the silica almost inoperative, ***and that the decomposition was practically complete at 48 litres per gramme-molecule.*** Calculation from the soda alone confirmed the result, being half its molecular weight. $NaHSiO_3$ gave a value of one half, equal to one of sodium and one of hydroxyl. $Na_2Si_5O_{11}$, selected because an analogous lithium silicate occurs in nature, gives a result which is similar, but the hydrolytic decomposition, as was to be expected from the law of mass, is not so far advanced at the same stage of dilution. K_2SiO_3 and $KHSiO_3$ were also in agreement, while lithium silicates were dissociated rather more easily, but followed the same law. Rubidium and cæsium showed signs of similar behaviour.

The conductivity was observed 5 or 6 hours after dilution, when the time and temperature factors observed by Kohlrausch had become constant. The determinations, compared with those specially made of the alkalies alone, confirm that author's opinion that the silicates in solution are hydrolytically decomposed into the hydroxide and colloidal silicic acid. Attention is drawn to the fact that in natural waters the recorded silica has never exceeded one gramme-molecule in 48 litres, and is generally very much less; consequently that the silica is always dissociated and in the colloidal state, which may account for various silicious deposits, some alterations of rocks, and certain absorptions by the roots of plants. The paper includes eleven tables of determinations.

S. G. R.

825. *Equilibrium of Stereoisomers.* **W. D. Bancroft.** (Journ. Phys. Chem. 2. pp. 143-158 & 245-255, 1898.)—The theory of Duhem (Zeitschr. phys. Chem. 22. p. 545, 23. pp. 193 & 497, 1897) is applied to numerous chemical substances. The mutual changes of two physical modifications of the same substance, with the equilibria attained at various temperatures, and the accompanying change in the freezing-point, are explained by a graphical method in preference to Duhem's analytical treatment. Instances are then adduced from the literature of organic chemistry of the variation of melting-point with the past history of the sample, and it is shown how these become intelligible in the light of the theory of allotropic change with variable reaction velocity. In the second paper the case of the presence of a third physical species (as an indifferent solvent, etc.) is considered.

B. B. T.

826. *Equilibrium of Stereoisomers of Acetaldoxime.* **H. R. Carveth.** (Journ. Phys. Chem. 2. pp. 159-167, 1898.)—The peculiarities in behaviour of the freezing-point of acetaldoxime noticed by Dunstan and Dymond [J. Chem. Soc. 61. p. 471 (1892), 65. p. 206 (1894)] are studied more fully and explained by means of Duhem's theory and Bancroft's diagram (see Abstract 825, above). The equilibrium is independent of the temperature and unaffected by sunlight. The stable triple point is 13° C. From acetone the β-modification does not crystallise out even at $-80°$ C. The liquefaction of the crystals is not accompanied by a measurable change of vapour-pressure; and it is probable that two modifications exist in the vapour.

B. B. T.

827. *Solubility of Naphthalene in Aqueous Alcohol.* **H. P. Cady.** (Journ. Phys. Chem. 2. pp. 168–170, 1898.)—Aqueous acetone from 10 to 70 °/₀ is saturated with naphthalene, and the temperatures determined at which the solutions separate into two layers. Tables are given from 30° to 70° C. No unsaturated solution of naphthalene in aqueous alcohol could be found that formed two layers on heating. B. B. T.

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828. *Electrolytic Deposition of Silver and its Separation from Copper.* **F. W. Küster** and **H. von Steinwehr.** (Zeitschr. Elektrochem. 4. pp. 451–455, 1898.)—Instructions for the electrolytic determination of silver are to be found in many text-books, but notwithstanding that such directions are carefully followed, the results obtained by the authors after many trials are always uncertain and usually unsatisfactory. The directions given err in insisting upon the maintenance of a certain current-density, instead of a constant E.M.F. In order that the metal may be precipitated in a weighable form, it is essential that the E.M.F. should not exceed a certain value; but as electrolysis proceeds, the concentration of the silver in the solution decreases and the resistance of the cell increases. If therefore the current is kept constant, the E.M.F. in the cell must increase, and may soon exceed the limiting value. Upwards of 100 experiments were made with a view to finding the most suitable experimental conditions. It was found that perfect precipitation is obtained when the solution (volume about 150 c.c.), containing about 0·5 gram of silver, is mixed with 1 or 2 c.c. of nitric acid, sp. gr. 1·4, and 5 c.c. of alcohol, the E.M.F. being kept constant at 1·35 to 1·38 volts for from 6 to 8 hours. Excellent results are obtained by this method of working, the maximum deviation from the mean of six analyses of an ordinary coin amounting only to 1 in 2000. J. W.

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829. *Electrolytic Reduction of Aldehydes and Ketones.* **H. Kauffmann.** (Zeitschr. Elektrochem. 4. pp. 461–464, 1898.)—The use of alcoholic soda for the solution of the compound is recommended in place of the bisulphate, as described in a previous communication. The kathode consists of a strip of lead, the anode of platinum foil; dilute soda is used as the anode fluid. Benzaldehyde is reduced to the two stereoisomeric hydrobenzoïns, and other aldehydes and ketones behave in a similar manner. Similarly, from benzil are produced tetraphenylerythritol and other compounds, the constitution and identification of which are discussed at length. Reduction by electrolysis is thus leading to results essentially different from those obtained by chemical means. J. W.

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830. *Electrolysis of Calcium Chloride Solutions.* **H. Bischoff** and **F. Foerster.** (Zeitschr. Elektrochem. 4. pp. 464–470, 1898.) —It was observed by Oettel that in the production of chlorates

by electrolysis, the behaviour of calcium chloride differed essentially from that of potassium chloride: in the former case, current-yields up to 87 °/₀ of chlorate can be obtained, whilst in the latter the yield seldom exceeded 60 °/₀. The authors conclude from their experiments that the explanation lies in the sparing solubility of the lime, which, forming a thin film on the kathodal plate, to some extent protects it from immediate contact with the solution, and restricts the reducing action of the current. The greater part of this lime of course reacts with the free chlorine from the anode to form hypochlorite and chlorate; but a not inconsiderable amount falls from the kathode, and collects at the bottom of the vessel out of reach of the chlorine. It is to be observed that barium chloride resembles potassium chloride in its behaviour on electrolysis, baryta being much more soluble than lime. The most suitable conditions for the production of calcium chlorate are found to be a concentration of at least 10 °/₀ of calcium chloride, a current-density of 0·001 ampere /cm^2 at the anode, and at least double this at the kathode. J. W.

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831. *Gutta-Percha.* **E. Obach.** (Soc. Arts Journ. 46. pp. 97–114, 117–133, 1897; and pp. 137–164, 169–197, 1898. Also Electr. Eng.) [The first part of these Cantor lectures is given in Abstract No. 537, p. 277, 1898.]—Besides the original species, many other trees such as Payena, called *Sundék* or *Soondie*, yield commercial sorts of very unequal value. "Gutta" is derived from the Malayan *getah*, meaning a viscous juice, "pertja" is a mistake in the name of the plant, the proper one being "getah tabu." The tree is entirely confined to a rectangular area (a map of which is given), 6° on each side of the equator and from 99° to 119° E. lat. The attempts at cultivation to replace the ravages created by cutting-down have been singularly unfortunate. It is propagated from seeds or by "marcottage" or laying. The yield of an adult tree may reach 2½ lbs., valued at 8*s.* 9*d.* It is extensively adulterated by the natives.

Composition and Analysis.—Pure gutta (Payen) $(C_{10}H_{16})_n$, the most valuable ingredient, is soluble in carbon bisulphide or chloroform, insoluble in alcohol, ether, or cold petroleum spirit. The latter solvents extract two oxidised resins—*albane*, crystallisable in needles, soluble in hot, but not in cold alcohol; and *fluavile*, yellow, amorphous, and soluble in cold spirit, besides a somewhat indefinite substance called "guttane." The commercial value of a crude sample is not only judged by the proportion between the pure gutta and the resin, deducting the water and dirt, classed together as "waste," but by the physical characters of the "pure gutta" itself. Materials in which the percentage of resin ("*r*") reaches or even exceeds that of pure gutta ("*g*") are of inferior quality. The name of "Pahang" is now applied to the best qualities, irrespective of the source. "Re-boiling" is an operation performed by the Chinese, who buy up odd lots, soften in hot water, and mix to a second-rate material. A large number of valuable commercial details, tables of analyses, valuations, figures of export and prices are given. Also a sketch of an apparatus for rapid proximate analysis.

Mechanical cleaning.—Brooman's apparatus (1845) washes and kneads the gutta between rollers in tanks of hot water. Hancock's (1847) slices, breaks, and minces under hot water, and then strains it by squeezing in the plastic state through fine wire-gauze. Masticating, mixing, and rolling machines follow, each of which are illustrated. The loss or "waste" during cleaning and drying sometimes reaches 50 °/₀, the actual yield being usually 6 to 9 °/₀ less than that indicated by analysis. The percentage of "waste" is now about twice as great as it was 20 years ago. Foreign bodies of large size are often fraudulently introduced into the blocks of raw material, and sometimes cause serious injury to the machines. The author has succeeded in discovering these extraneous matters by the X-rays, to which gutta-percha is exceedingly transparent.

Chemical washing.—Caustic alkali and chloride of lime neutralize acidity, remove odour, and produce a lighter colour, but the process requires great care and thorough subsequent washing.

Chemical hardening, introduced by Obach 20 years ago, is the extraction of resin by petroleum spirit of 0·65 to 0·67 sp. gr. The material is chopped, dried, and percolated with spirit, which is re-distilled and used again; finally the purified gutta is masticated and kneaded with steam.

The mechanical properties of gutta should be greatly improved by hardening, while the electrical ones should be only slightly affected. But in practice the commoner sorts, which are usually selected for this treatment, contain also a gutta of inferior description, hence the product, though low in resin, is not equal to the superior kinds obtained directly from the tree. It possesses, however, much greater toughness at low temperatures, hence would be valuable for ice-boats: at present it is used in large quantities for golf-balls.

Chemical extraction.—Carbon bisulphide and other solvents easily separate the "waste," but the product obtained on evaporation quickly perishes, probably on account of molecular alteration. On the other hand, precipitation of the solution by alcohol separates the pure gutta from the resins, and is frequently practised.

Extraction from leaves and branches.—The reason for the destruction of the trees is that the juice does not flow so freely by tapping as when they are felled. But 6 years ago it was proposed to utilise the branches, twigs, and leaves, which can be removed at intervals without injury to the plant. In this way adulterations would be prevented, as the leaves are easily distinguished by the veins, etc. When a leaf or stem of *Palaquium gutta* is torn asunder, a web of fine white threads will be seen stretching across the gap: these are coagulated latex, and in inferior species they are not so numerous or tenacious. A tree 10 years old yields about 15 lbs. of dry leaves; at 30 years it yields 25 lbs.; therefore if regularly plucked, the total product would be 420 lbs. containing 9 to 10 % of gutta, or 40 lbs. nett, *i.e.* at least 20 times as much as if felled and bled in the customary way. On the other hand, the bulk of the leaves is about 15 times that of the raw gum as exported.

Three patented processes for the extraction are described and figured. Rigole in 1892 employed CS_2 and steam, afterwards evaporating; while in the same year Sérullas introduced hot toluene, precipitating the gutta by means of acetone, in this way obtaining a pure and preferable article. Ramsay has recently suggested *resin oil* instead of toluene. A company has lately been floated for working the Sérullas process. Lastly Obach makes use of a single liquid, boiling petroleum ether, crushing the leaves between rollers: on cooling the solution below 60° F. the pure gutta is completely precipitated. No satisfactory *mechanical* process has hitherto been devised.

Natural substitutes.—Obach and others have examined a large number of "pseudo-guttas," but the only one of real value is *Balata*, the latex of the "bullet tree," a *Sapota* or *Mimusops* from Jamaica, Trinidad, Venezuela, the Guianas, and other regions. The trunk is tapped, as the latex is more liquid than that of gutta-percha. A gallon of milk yields by evaporation 4 lbs. of pinkish or greyish balata, fetching 10*d.* or 11*d.* per lb. Original analyses are given, from which it appears that the sp. gr. is about 1·006, that the gutta is strong and tough and probably identical with that from the *Palaquium*, but that the amount of resin is so large "that the material can only be regarded as a substitute for second, or perhaps even third class gutta-percha." The average price in London is 1*s.* 10*d.* per lb.

Artificial substitutes are numerous. Mourlot in 1878 prepared an insulating material, "Gutta française," from birch-bark by distillation, at 2·5 francs per kilo. It was said to render gutta more durable and to protect it against the attacks of rats, but the lecturer's opinion of it was not favourable. "Velvril" is a compound of collodion cotton and nitrated castor or linseed oil. It is moulded in manufacture, but when once hardened cannot be softened by heat alone. "Chatterton's compound," a mixture of gutta, colophony, and Stockholm tar, is largely used as a binding material in cables.

Numerous diagrams and statistics, and elaborate tables of compositions and physical properties, with descriptions of applications and of the behaviour towards oxygen and ozone, conclude a most valuable monograph on the subject. S. G. R.

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832. *Electrolytic Alkali by the Hargreaves-Bird Process.* **J. B. C. Kershaw.** (Electrician, 40. pp. 547–549, 1898.)—This article contains a description of the experimental electrolytic plant at Farnworth, with details of the observations and tests made on the occasion of two personal visits of inspection, in November and January last.

The motive power is supplied by a 20 H.P. gas-engine, and the whole of the electrical energy developed is utilised in one large electrolytic cell, constructed according to the Hargreaves-Bird arrangement. The two side walls of this cell form the combined kathode-diaphragms, and each has a superficial area of 50 sq. feet. The kathode area of the cell is therefore 100 sq. feet.

A peculiar form of compound anode, the invention of Mr. Connor of Belfast, is used in the inner anode chamber of the cell. The brine in this chamber is kept at a high temperature by the heating effects of the current, and of the steam in the outer kathode chambers. On the occasion of the writer's visits the temperature was 70° C. The normal current with which this cell is worked is 2200 amperes, and 224 lbs. of dry salt are decomposed in it per 24 hrs. Details of two runs are given in the article. The current efficiencies were 92·7 %, and 90·4 %, while the energy efficiencies were 50 % and 48·9 %. These percentages have been worked out upon the same basis as that used in an earlier article by the writer upon electrolytic soda and bleach. Two illustrations help to elucidate the text. AUTHOR.

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833. *Bullion Refining.* **J. B. C. Kershaw.** (Electrician, 41. pp. 187–189, 1898.)—In this article the writer deals with the refining of gold bullion, with especial reference to the parting of gold from platinum. In the historical notes upon the subject, he describes the chemical method introduced by D'Arcet into Paris in 1802, and by Matheson into London in 1829. The modification of this original method known as the "Gutzkow process," and used down to the present date, is then described. A detailed account of the electrolytic method worked out by Dr. Wohlwill and his assistants at the Nord-deutsche Refinery, Hamburg, in the period 1878–95 follows. This process depends upon the use of the impure gold bullion as anode in a hot solution of auric chloride containing excess of hydrochloric acid, or of the alkali metal chlorides. The kathodes are formed of thin sheets of pure gold, hung at a distance of 3 cms. from the anodes. The current-density used varies from 95 up to 190 amperes per sq. foot, and at the lower density an E.M.F. of 1 volt is found sufficient to drive the current through each vat of the series. The silver is found as insoluble silver chloride in the anode slime, with some gold. The platinum and palladium pass into solution, and are recovered at long intervals by chemical means. If the bullion contain only 1 part of platinum per 1000, with a daily treatment of 20 kilos, 2 kgs. platinum will be collected in the electrolyte in the course of 100 days. This process has been in operation for some time at the works of the "Frankfürter Gold und Silber Scheide Anstalt" at Hamburg, where a plant covering only 64 sq. feet of ground-space suffices to produce 75 kgs. fine gold per 24 hours.

A considerable portion of the article is devoted to the chemistry of the process, and to Dr. Wohlwill's explanations of the changes occurring in the electrolyte. The latter has discovered that gold will not dissolve unless the conditions favour the formation of salts of the type AuClMCl, or AuCl,MCl; and it is the non-recognition of this fact that has hindered the development of an electrolytic process for refining gold. Space is also given to Dr. Wohlwill's theory regarding the origin of the gold found in the anode slimes.

The article concludes with a prophecy of the writer that the electrolytic method of gold refining will ultimately displace the older chemical methods, by reason of its greater economy, simplicity, and cleanliness. AUTHOR.

834. *Electrolysed Sea-water for Disinfecting.* **W. L. Hedenberg.** (Elect. Engin. 21. pp. 681–682, 1898; also 'Electricity,' N. York, 14. p. 296, 1898.)—The author in this short article discusses the Woolf and the Hermite systems of sewage disinfection. After some general remarks upon the problem, he gives an account of the former as used experimentally at Brewsters, at Riker's Island, and at Danbury. The process was first tried at Brewsters, New York, in 1893, with a plant comprising a 15 H.P. engine and a dynamo yielding 700 amperes at 5 volts. The most striking effect gained here was the diminution of Bacteria in the sewage-contaminated water; the number being reduced from 22,000 to 42 per cub. centimetre. The system was operated at Riker's Island, the dumping-ground for New York's garbage, in 1894. A plant capable of producing 4000 gallons of the disinfecting fluid per hour was mounted upon a barge, and the fluid was sprayed upon the heap at various points by means of a pump and lines of hose-pipe. The results, from a sanitary point of view, were successful.

At Danbury, Conn., the system was used to disinfect the sewage of the town before discharge into a neighbouring river. The plant comprised a 40 H.P. engine and a dynamo yielding 1000 amperes at 5 volts. The disinfecting fluid produced was mixed with the sewage, in a special mixing-tank provided with agitators, before the sewage was discharged into the river. The results were not satisfactory, since the solid matters of the sewage remained unacted upon, and later occasioned trouble; and the system has been abandoned at this place. Two illustrations are given, of Woolf plants in U.S.A.

The remainder of the article deals with the experimental trials of the Hermite system in England, France, and India, and contains little information not to be found in the earlier article on the Hermite process by Kershaw in the same paper (see Abstract, No. 842, 1898). J. B. C. K.

835. *Electrolytic Treatment of Tin Residues.* (Ind. Électrochim. 2. pp. 2–3, 1898.)—In the manufacture of vessels of tinned iron there is a loss through waste of 6–7 %, which, together with old rejected vessels, amounts to thousands of tons annually. The difficulties in the treatment of these residues arise from their large

bulk, and from the presence, under the layer of tin, of an alloy of tin and iron. In some works caustic soda solution is used as an electrolyte, which dissolves the tin, but not the alloy of tin and iron. The iron left has therefore but little commercial value, owing to the relatively large proportion of tin still retained by it. In another recent process the scraps of metal are packed in wood frames and serve as the anode, while the tin is deposited upon kathodes of tinned copper. Dilute sulphuric acid is used as the electrolyte, and the iron is eventually completely dissolved and converted into the crystalline sulphate. J. W.

836. *Electrolytic Treatment of Nickel Ores.* (Ind. Électrochim. 2. pp. 12–13, 1898.)—The crude *matt* obtained by the Canadian Copper Company contains approximately equal parts of nickel, copper, iron, and sulphur, besides traces of gold, silver, and platinum. It is repeatedly fused with coke and sodium sulphate, whereby a fairly pure nickel sulphide and a copper slag are produced. The latter are lixiviated to remove sodium salts, reduced in a reverberatory furnace, and the copper cast into anodes and refined in a bath of the sulphate. The mud collecting in the bath is worked up for the precious matal. The nickel sulphide, on the other hand, is roasted with salt and lixiviated. Copper, gold, and silver pass into solution as chlorides and sulphates, and are afterwards precipitated. The nickel oxide remaining undissolved is reduced in a reverberatory furnace, and cast into anodes containing 95–96 °/₀ of nickel. These are taken by the Balbach Smelting and Refining Company of Newark, and refined by the ordinary electrolytic process. The metal produced contains 99·5–99·7 °/₀ of nickel, with traces of copper, arsenic, sulphur, iron, and platinum. J. W.

837. *Electrolytic Treatment of Complex Ores of Zinc, Lead, and Copper.* (Ind. Électrochim. 2. p. 13, 1898.)—According to the process of E. C. Ketchum of Boston, the ore, after a preliminary roasting, is treated with a hot 25 °/₀ solution of caustic soda. Zinc and lead are dissolved; iron, silver, and copper being unattacked. The solution is run into a series of electrolytic bath tanks, and the lead precipitated upon iron kathodes by a current at 1·8 volts. The zinc remains in solution, and is precipitated upon zinc sheets, in a second series of tanks, by a current at 2·1 volts. The drawbacks to the process are the high price of the soda solution and its rapid carbonation on exposure. J. W.

838. *Hypochlorite of Soda by the Tailfer Electrolytic Cell.* (Ind. Électrochim. 2. pp. 18–19, 1898.)—In this apparatus the sodium hydrate and the chlorine produced by the electrolysis of a solution of common salt are allowed to react in a separate vessel provided with an agitator, called the "Absorber." The electrolytic cell itself is provided with anodes of gas-carbon and kathodes of iron, sepa-

rated by asbestos diaphragms. The anode compartment is closed above, and its side walls are formed by these diaphragms. The strength of the hypochlorite solution obtained depends upon the concentration of the sodium hydrate solution run into the "absorber," but it is not always profitable to attempt to utilise more than 50 % of the sodium chloride. A calculation is necessary in order to ascertain the most favourable conditions of work for each individual case.

M. Tailfer gives details of the first cost of a 20 H.P. installation, and of the costs of running the same. If water-power be available, he estimates that a saving of between 40 and 50 francs a day is effected by the use of the electrolytic method for production of sodium hypochlorite; while if steam-power be used, the saving is reduced to 25 francs daily. With larger installations the saving is more striking, since the working costs remain practically stationary. J. B. C. K.

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839. *Electro-Deposition of Iron.* (Ind. Électrochim. 7. pp. 20–21, 1898.)—The electrolysis of iron salts has hitherto been made use of for the preparation of iron in the state of powder, for the strengthening of stereotype plates, and for the steel-facing (*acierage*) of small articles. According to the conditions, the metal may easily be obtained either in a pulverulent form, or as dense and hard as tempered steel. The dense product contains a large amount of occluded hydrogen, sometimes as much as 200 times its volume. For the production of the powder the use of citrate or oxalate of iron is to be preferred; but the regulation of the current-density is the most essential point to be observed. For the production of dense coherent deposits, sulphate of iron is almost always used. The metal deposited from solutions of the chloride has a tendency to oxidise rapidly, and the presence of chlorides should therefore be avoided. The solution of the sulphate should be neutral, and, according to the majority of the various modes of procedure, is mixed with a certain proportion of sulphate of ammonium, sulphate of sodium, or sulphate of magnesium. Sometimes the iron deposited is afterwards oxidised and a fine bluish-black layer of magnetic oxide obtained, nearly as hard as iron. In all cases anodes of iron are employed of the same dimensions as the kathodes; the current-density varies from 0·15 to 0·45 ampere per sq. dcm., and the E.M.F. required is 1 to 1·3 volt. J. W.

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840. *Electroplating Plants.* **C. F. Burgess.** (West. Electn. 22. pp. 195–197, 1898.)—This article gives a careful review of the various conditions which have to be fulfilled in order to obtain economical working. C. K. F.

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841. *Sterilisation of Water by Ozone.* **E. Andréoli.** (Électricien, 15. pp. 226–229, 1898.)—A critical notice of the report of Professors van Ermengen and Gérard upon the exhibit of the

Tindal ozoniser and sterilising apparatus at the 1897 Brussels Exhibition. The exhibit comprised a Mordey dynamo, a Schneller transformer, and a Tindal ozoniser and steriliser. The dynamo yielded a current of 30 amperes at 80 volts, which was raised in the transformer to a very high voltage. In the ozoniser, air specially dried was submitted to the silent discharge of the high-tension current; and the ozonised air was then used in the steriliser for purification of Brussels water.

The author in the first place criticises the method used by the Professors for determination of the ozone. It is one designed for the estimation of ozone in oxygen, and its author, Dr. Houzeau, has stated that it is inapplicable when nitrous compounds may be present. As regards the output of ozone per k.w., the figures published by the Professors show that 2400 litres dry air passed through the ozoniser per hour, and that the amount of ozone present at the exit varied from 3·0 to 4·3 grams per cub. metre of air. The consumption of electrical energy per gram of ozone produced, worked out to between 244 and 252 watts. The electrical energy per cub. metre of water sterilised varied from 75 to 95 watts. If this energy be supplied at a cost of 10 centimes per k.w., the cost of treatment will lie between ·80 and 1·0 centime per cubic metre (35·3 cubic feet) of water. The Professors close their report with the statement that the Tindal ozoniser appears to convert the whole of the electrical energy into ozone. The author strongly dissents from this statement, and asserts that the theoretical yield of ozone is 1030 grams per H.P. hour, while many ozonisers yield 10–20 times as much ozone per H.P. hour as the Tindal ozoniser. The low efficiency of the latter form of ozoniser is attributed by the author to the absence of a dielectric plate between the opposing electrodes, and to the use of a glycerine-and-alcohol resistance-cell in the circuit. The former causes indirect loss by heating of the air and decomposition of the ozone already formed; the latter occasions a direct loss by reduction of the voltage of the current used. In the author's opinion, the results of the tests with this apparatus at Brussels are encouraging to owners of ozonisers which have from 10 to 20 times the efficiency of the Tindal ozoniser, since they show how little ozone is sufficient to sterilise an ordinary drinking-water.

The Tindal apparatus is to be installed shortly on a large scale at Paris. J. B. C. K.

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842. *Electro-Chemical Industries of Europe.* **J. B. C. Kershaw.** (Electricity, N. York, 14. pp. 116, 147–149, 196, 244, 280–281, 311–312, 1898.)—In articles 15–20 of the series which have been appearing in this paper since August of last year, the writer deals with the Hargreaves-Bird Process, Organic Products, the Hermite Processes, Magnesium, Chromium and Nickel, Bullion Refining, and Electrolytic Tin.

The facts and figures contained in Art. 15, upon the Hargreaves-Bird Alkali Process, have already received notice (see Science

Abstracts, No. 832).—In Art. 16, the applications of Electrolysis as an aid in the manufacture of organic chemicals and dyes are dealt with. According to the writer, Iodoform and Chloral are produced by electrolytic processes by the firm Vorm. E. Schering, of Berlin; Yellows and Congo-reds, at Ludwigshafen, by the Badische Anilin u. Soda Fabrik; and Aniline dyes by Fried. Bayer u. C^{ie} at Elberfeld. Upon the authority of Oettel it is also stated that "nearly every German colour-works is provided with an electric installation, and the necessary accessories for electrolytic work." The production of Cyanides and Ferro-cyanides by Readman's process, which is shortly to be worked in Scotland, is also briefly noticed.—Article 17 deals with the Hermite bleaching and disinfecting processes. The plant at Stjernfors, Sweden, for bleaching wood-pulp, and the disinfecting plant erected at Ipswich, England, are described in detail. The writer considers that electrolytic bleaching processes have a future; but he is somewhat sceptical regarding the success of the processes for disinfecting sewage.

The electrolytic production of Antimony, Chromium, Magnesium, and Nickel is the subject of Art. 18. Electrolytic antimony has been put upon the metal market in Europe, and a description of the Siemens and Halske process, which the writer believes has been used in its production, is given. Chromium is produced at the Elektro-chemische Werke, Bitterfeld, probably by an electric-furnace method similar in principle to that used by Moissan. Magnesium is produced at Hemelingen, at Trotha, and at Bitterfeld by electrolytic methods; and a detailed account of the process used at the former place is given. Electrolytic nickel is produced by two Firms in U.S.A. and one in Germany. The principle of the method used in all three cases is the same. A copper-nickel matt is cast into anodes, and is used in a bath of copper and nickel sulphates. When the electrolyte is acid, copper alone is deposited; when neutral, the nickel also separates at the kathode. The writer states his opinion that, as regards chromium, magnesium, and nickel, the electrical processes will have a successful future.—Article 19 relates to Bullion Refining. The Mœbius Silver-refining process is in operation at Frankfort in Germany, and at St. Louis and at Perth in U.S.A. The Wohlwill Gold-parting process is in operation at Hamburg. A detailed description of the plant at Frankfort is given, together with some details of the Wohlwill process as operated at Hamburg. Brief mention is made of the Rossler-Edelmann process for recovering the silver from argentiferous lead. The writer considers that, as regards the precious metals platinum, silver, and gold, the electrolytic parting methods will entirely displace the older chemical methods.—In Art. 20 the Recovery of Tin from tin-scrap, and the Refining of Commercial Tin are dealt with. As regards the first, the processes of Siemens and Halske, of Smith, and of Claus receive notice. The two former are stated to be at work in Germany; while use of the latter, on the authority of Claus, is about to be made in England. The electrolytic refining of tin, as carried out at Messrs. Bolton's works in Staffordshire, is described. The writer calculates that 193·8 E.H.P. days of 24 hrs. would be requisite to produce 1 metric ton of pure tin by any of these processes; and taking the cost of the E.H.P. hour at $·002 (=$\frac{1}{10}$*d.*, *i. e.* the cost of electrical energy at Niagara), he estimates the cost of electrical energy per ton of tin at $9·30 (=38*s.* 9*d.*). He therefore considers that the electrolytic recovery of tin from tin-scrap would prove a profitable industry, if the scrap could be collected at a reasonable cost. AUTHOR.

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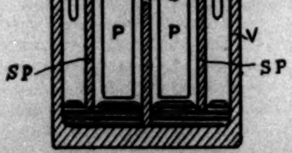
843. *Electric Furnaces.* **G. Richard.** (Écl. Électr. 13. pp. 481–486, 1897.)—This is an illustrated and detailed description of the chief electric furnaces at present in use. Amongst those described are the furnaces due to Patten, Eldridge, Wright and Clark, Denther, Bullier, Price, and Combes. W. G. R.

GENERAL ELECTRICAL ENGINEERING.

844. *Accumulator Plates.* **H. Weyer.** (Elektrochem. Zeitschr. 4. pp. 198–208, 1897.)—A *résumé*, unsuited for abstraction, of improvements recently made in the construction of the essential parts of accumulator electrodes. References are given to upwards of a hundred patents. J. W.

845. *Mouterde Accumulator.* (Elektrochem. Zeitschr. 5. pp. 10–13, 1898.)—The electrodes are cylindrical. The outer one, which also serves as the containing vessel, is a cylinder of lead strongly ribbed on its inner surface with horizontal ridges. It forms the positive electrode, the active material being contained in the furrows between the ridges. The negative electrode consists of a smaller cylinder with ridges on its outer surface; these ridges are made of somewhat greater depth than those on the positive electrode. A thin envelope of perforated lead surrounds the negative electrode, and prevents the active material from dropping out. The rates of charge and discharge are said to be exceptionally high. It is also claimed by the inventor that a series of short-circuits increases the capacity of the cell, and this view appears to be borne out by the results of some experiments which are quoted. A. H.

846. *Mercury Switches.* **P. Janet.** (Ind. Élect. 7. pp. 96–98, 1898.)—The author describes a form of mercury switch, the essential parts of which will be understood by reference to the sketch given below. V is a vessel of insulating material divided into



two compartments by an insulating partition which is perforated at *a*. Two subsidiary partitions SP extend from the top of the vessel to within a short distance of the bottom. T_1 and T_2

are the terminals. The vessel contains mercury, and by lowering the plungers PP the mercury is forced up, making contact first with T_1 and T_2 and then completing the circuit through *a*. It is evident that the *break* takes place between the two mercury columns at *a*. For high-pressure circuits the vessel is divided into a larger number of compartments, so as to have several mercury breaks in series. The author states that such switches have been tried on 3000-volt circuits. A. H.

847. *Commercial Tests of Accumulators.* **E. Hospitalier.** (Ind. Élect. 7. p. 129, 1898.)—In testing storage-cells for capacity and efficiency, there are three different methods of procedure, each giving different results. First, the cells may be discharged through a constant resistance. Second, the current may be kept constant; and, third, the power taken from the cells may be kept constant. Of these methods the first is the simplest and leads to the best results. The discharge should in all cases be continued till the E.M.F. (on open circuit) of the cell falls to 1·8 volts. The author thinks that there should be uniformity of method in commercial testing of storage-cells so as to render a comparison of their respective merits possible. W. G. R.

848. *A new Fuse.* (Lightning, 13. p. 358, 1898.)—This new fuse, which is due to F. J. Borland, contains two fuse wires: one of these is much thinner than the other. In the normal state all the current passes through the thin wire, but on this fusing a bar which it supports falls and makes contact in a mercury cup, thus cutting in the thicker wire which will not fuse unless something is radically wrong. W. G. R.

849. *A Lightning Arrester.* **R. B. R.** (Ind. Élect. 7. pp. 158–160, 1898.)—The object of the apparatus here described is:—

1. To conduct to earth in a definite way all atmospheric discharge taking place on high-tension lines.
2. To prevent a prolonged short-circuit between the line and earth.
3. To automatically reset itself after discharge.

The lightning arrester made by the Société d'Électricité Alioth fulfils each of these conditions, and is constructed as follows:—Fixed on a cast-iron frame are three porcelain slabs placed one above the other. The uppermost slab carries a brass terminal which is connected with the line to be protected. This terminal carries a carbon disc, opposite to which is another carbon disc attached to the end of an aluminium lever capable of rotation round a fixed point, and worked by means of an electromagnet. The lower end of the lever is connected to earth, and the distance between the carbon discs is such as to render impossible a discharge under the line-voltage only. W. G. R.

850. *Automatic Alarm for Hotels.* (Elekt. Runds. 15. pp. 119–120, 1898.)—An illustrated description of an invention by which bells may be sounded at different times, as desired, in different rooms of a hotel by a revolving contact-drum which closes each circuit at the required time. A. H.

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851. *Electrical Low-water Alarm.* **Brown.** (Elect. Engin. 21. pp. 468–469, 1898.)—A mercury tube is encased, above normal water-level, in a metal fitting attached to the boiler front by a pipe with internal elbow, having its mouth at low-water level. Water or steam surrounds the mercury tube according as the water-level is above or below the elbow-mouth. As the mercury expands with the higher temperature of the surrounding steam, it makes contact with the ends of two platinum wires, so closing the circuit of an electric bell. A. S.

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852. *Station Photometry.* **B. Speed.** (Elect. World, 31. pp. 440–441, 1898.)—This article has been written to supply electrical engineers engaged in Station work with explicit and detailed directions for the construction and operation of a photometer department. The screen recommended is a Bunsen grease-spot. The standard of illumination is an incandescent lamp standardised by reference to carefully chosen standard candles, directions as to the choice and manipulation of the candles being given. Before using any lamps from a fresh consignment, one or two should be taken from the lot at random, and completely tested to see whether they fulfil the contract for life and candle-power. If these fail to fulfil the conditions two or three more should be tested, and if these fail the lot should be returned to the maker. W. G. R.

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853. *Electric Drilling Machines.* (Electrician, 40. pp. 849–850, 1898.)—The drill here described, and made by the Thames Ironworks, is driven by a shunt-wound overtype bipolar motor, the drilling machine being coupled to the motor and driven by a bevel-wheel and pinion. The machine stands on two stout limbs of an electromagnet which serves to grip the work and resist the thrust due to the feed of the drill. The ratio of reduction of speed can be altered by changing the set of gear-wheels at the motor. These machines have become indispensable for use in positions where the work would otherwise have to be done by hand. W. G. R.

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854. *Three-Phase Machinery.* **W. M. Venable.** (West. Electn. 22. pp. 208–209, 1898.)—The chief feature of this article is the novel way in which the author explains why three wires only are necessary in a three-phase installation. Considering first three separate and independent alternators, six wires would be

necessary. If the three machines are connected together at one terminal only, the effect would only be to bring those terminals to a common potential without altering the potential difference between any pair of terminals; hence two wires can be dispensed with and a common return used. But in a three-phase the sum of the three currents is always zero, so that this common return may be cut out and three wires only remain. W. G. R.

855. *Submarine Torpedo Boat 'Holland.'* (Elect. Rev. N. Y. 32. pp. 211–212, 1898.)—This boat, which is 56 feet long, is propelled by a single screw driven by a direct-current motor having a normal capacity of 50 horse-power. Current for the operation is derived from 60 special-type chloride accumulators having an aggregate weight 45,000 pounds. These cells are capable of discharging 300 amperes for six hours. On spurts of speed lasting for about half an hour, the discharge rate may be increased to 1000 amperes. The battery-cells are constructed of steel, lined both inside and outside with lead. The ventilating of the boat when submerged is done by means of a one-half horse motor which drives out the foul air, fresh air being obtained from reservoirs. W. G. R.

856. *Balancing of Engines.* **J. Whitcher.** (Elect. Engin. 21. pp. 459–462 & 488–492, 1898.)—The author discusses the subject in non-mathematical language, with special reference to inertia pressures on the bearings, and speed-limiting conditions. He divides bearings into three classes, in which the direction of the pressure is constant, alternating in direction, and rotating or oscillating over an arc of a circle. The principle of rotary-bearing pressure seems to afford a feasible method of passing the speed limits possible with constant or alternating pressures. The perfect balancing of the connecting-rod engine is a matter of great difficulty, and in practice approximations only are obtained. The author has invented two methods of balancing. In one the connecting rod is extended beyond the crank-pin a distance equal to its length between crosshead and crank, a weight equal to that of piston and crosshead is attached there, and a counter-weight is attached to the shaft opposite the crank-pin. In the other method, two links of length equal to the connecting rod swing about fixed axes, the plane of their motion being the same as that of the connecting rod. The paper is illustrated by eight figures. A. S.

857. *Automatic Electromagnetic Block-Signal.* **W. Boult.** (Zeitschr. Elektrotechn. Wien, 16. pp. 65–68, 1898.)—The signalling is effected, not by discs or arms on the line, but by two small

aluminium arms in glass cases on the driver's platform of the engine. The difficulty of getting a reliable electrical connection between the signal-box and the driver's platform of the moving train is avoided. On the locomotive two groups of cells operate the signals; these are brought into action by means of a U-shaped bar of soft iron, which is magnetised on passing a magnetic field on the permanent way. A diagram illustrating the mode of operating is given. A. S.

DYNAMOS, MOTORS, AND TRANSFORMERS.

858. *Prevention of Commutator Sparking.* **J. Fischer-Hinnen.** (Ind. Élect. 7. pp. 70–73, 1898.)—The paper contains a brief account, with criticisms, of the various devices used for the prevention of sparking—such as Ryan's, Swinburne's, the author's, Sayers', Mordey's, and Brown's. The author suggests a special form of winding for a four-pole armature intended for use with laminated field-magnets in an alternate-current motor. A. H.

859. *Armature Windings.* (Zeitschr. Elektrotechn. Wien, 16. pp. 17–23, 1898.)—This is an elaborate yet lucid paper on the theory of the windings of closed-coil continuous-current armatures. The writers establish the conditions (*a*) that the winding shall be simple (*i. e.* consisting of a single closed circuit), and (*b*) that each conductor shall be used once only in stepping round the armature. They then establish the general formula

$$\frac{y}{b}=\frac{1}{p}\left(\frac{eC}{b}\pm a\right),$$

where

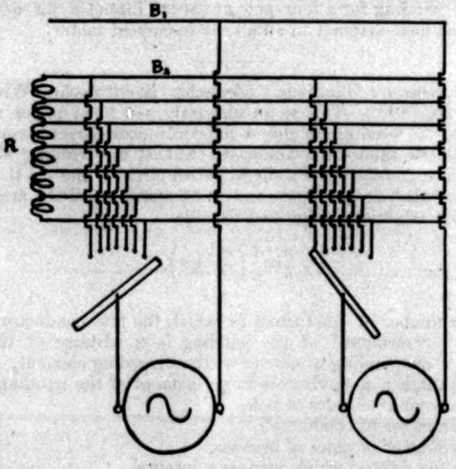
y=number of conductors by which the first conductor of an "element" of the winding is in advance of the corresponding conductor of the preceding element,
b=number of conductors in an element of the winding,
p=number of pairs of poles,
C=number of conductors,
a=number of pairs of brushes,
e=any integer which renders y integral.

The above formula is somewhat more general than that given by Arnold. Its use is exemplified by the consideration of a number of special cases. A. H.

860. *Multipolar Armature Windings.* **A. L. Rice.** (Amer. Electn. 10. pp. 149–152, 1898.)—This is a continuation of the article abstracted in Abstract No. 442. The author gives descriptions and diagrams of a four-pole lap winding in two layers, a six-pole wave winding in two layers, and a four-pole two circuit gramme winding. In this last case the armature is connected up in series by connecting each coil to a commutator bar nearly at right angles to the coil, and carrying on a connection from this commutator bar to another coil nearly opposite the first one. R. B. R.

861. *Paralleling of Alternators.* **J. Sahulka.** (Zeitschr. Elektrotechn. Wien, 16. pp. 114–115, 1898.)—The author describes the method commonly used by Ganz & Co., in which the alternator

to be thrown into circuit is first run up to the proper E.M.F. on an artificial load at the central station, then brought into phase with the other machines and connected to the bus-bars—the artificial load being afterwards gradually removed. A serious objection to this method is that it involves a temporary increase in the total load whenever a new machine is coming into circuit. The author has devised the method illustrated in the accompanying diagram, in which B_1 and B_2 stand for the bus-bars, and R denotes



a reactance coil with subdivided winding connected to a multiple-contact starting switch. In starting a new alternator, the corresponding switch is moved over the successive contacts, the exciting current being at the same time adjusted so as to give the proper potential difference across the terminals. By this means the alternator is pulled into synchronism as soon as the switch closes its circuit, without appreciably disturbing the other machines.

A. H.

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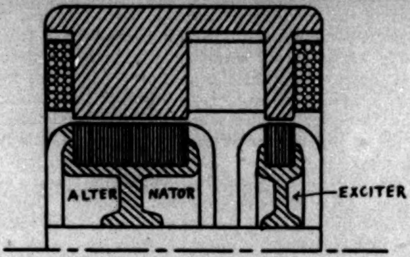
862. *Self-regulating Alternator*. (Elekt. Runds. 15. pp. 96–97, 1898.)—The following extremely ingenious method, due to E. Danielson, of Stockholm, enables the compounding of an alternator to be carried out without any necessity of rectifying the current. The exciter armature is mounted on the alternator shaft, as shown in the accompanying sketch. The same field-winding does for both alternator and exciter (the latter being series-wound). The regulation is effected by a supplementary winding *on the armature* of the exciter, which is supplied with an *alternating* current (either the main current of the machine or a

transformed current). This winding is so arranged with respect to the ordinary winding that the current in the latter is opposed to that in the former; and it is so proportioned that when the



alternating current is in phase with the E.M.F., the exciter armature reaction strengthens the field sufficiently to make up for the drop due to resistance and inductance in the alternator armature. If now the alternating current should lag behind the E.M.F., the armature reaction in the exciter will be increased so as to strengthen its field, and hence also the exciting current and field of the alternator, so that the P.D. across the terminals of the latter will remain unaltered. The method therefore possesses the advantage that it is capable of compensating automatically not only for the ordinary drop due to resistance and inductance, but for armature reaction brought about by phase shifting as well. It is equally applicable to single-phasers and polyphasers. A. H.

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863. *Crocker - Wheeler Slow-speed Motors.* **G. S. Dunn.** (Elect. Engin. N. Y. 25. pp. 400–402, 1898.)—The 2 H.P. slow-speed motor runs at 100 revs. and has 8 poles and 8 brushes. The brush-spindles are connected to two rings, the positive brushes to one and the negative to the other. These rings are rigidly connected but insulated from one another. The rings are placed next to the armature, leaving the commutator clear and easy of access. The author points out a characteristic of slow-speed motors which in certain cases gives them an important advantage over others. Their moment of inertia is low and permits starting from rest in a minimum of time with a minimum of current. In the case of the 2 H.P. 100 revs. armature, the product of the moment of inertia by half the square of the angular velocity is 280 foot-lbs., while in the case of the 2 H.P. 1000 revs. motor it is 900 foot-lbs. Where the duty the motors have to perform requires quick and frequent starting and stopping, this difference is very noticeable and plays an important part in the economy of the plant. The regulation, however, is much less perfect with slow-speed motors. A 5 H.P. motor at 950 revs. will slow down 4 °/₀ when full load

is put on; but a 4 H.P. motor at 200 revs. will slow down 15 % under the same conditions. In shunt motors the field is controlled by a rheostat, or is wound in multiple sections, whose circuits are opened successively. Series motors have their speed controlled by short-circuiting various portions of the field. Compound motors have a constantly excited shunt, and a series field in two sections, or they have an unvaried series-coil with a shunt-coil whose strength is changed by a field regulator. All these motors are designed to be capable of an increase of 50 % above normal, and a decrease of 10 % below normal speed. Two kinds of controllers are used: the cylinder reverses giving as many speeds backwards as forwards. operating through a resistance, regulating the speed by cutting down the voltage supplied by the line; and a commuter, specially designed for use with a compound motor. The commuter varies the speed by changing the connections of the various field-coils. Three diagrams of cylinder reverses are given, for shunt, series, and compound motors, and one of a commuter. R. B. R.

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864. *Fan Motors.* (Elect. World, 31. pp. 407–411, 1898.)—This article describes the various types of electrically-driven ventilating fan on the market. Amongst the direct-current motors described is the Lundell motor with a single field-coil arranged obliquely around the two pole-pieces and the armature, the outer shell or casing forming the magnetic yoke; the Western Electric motor; and the Paragon motor. The Seller's type of bearing is usually employed with special lubricating devices. Of the low-speed motors, the Western Electric is described. In the self-starting single-phase alternating-current motor of the General Electric Co. (U.S.A.), the winding of the rotor or armature consists of bare copper rods run through slots in a laminated core and riveted into copper rings at either end. The rotary action of the field necessary for starting the motor is obtained by the use of "shading coils," *i. e.* short-circuited copper loops surrounding a part of a pole on which is placed the active primary winding. The currents set up in these loops lag behind the currents in the active winding, and hence set up a magnetisation in the sections of the poles on which they are wound out of phase with that in the other sections and give a rotating field. These short-circuited sections, however, constantly waste energy while the motor is running. In the Emerson motor, the arrangements for producing the phase-displacement can be cut out when the motor is brought up to speed. In the Tuerk motor for driving low-speed fans, the rotor runs at a fairly high speed and is provided with a pinion which drives the fan-shaft through leather-faced friction wheels shaped as frustra of cones and mounted on hinged inclined shafts; these wheels bear against the inside of an outer shell carrying the fan-blades, the proper pressure between the parts being maintained by hanging the shell and fans on these friction-wheels. The Wagner, Standard, and Diehl motors are also described, and also a

synchronous motor due to Mr. R. Lundell which prevents the occurrence of lagging or idle currents in the supply system. This motor has an external primary built up of laminated iron with 8 internally-projecting poles each wound with a coil supplied with alternating current. The internal rotating armature is laminated, slotted, and wound with two circuits, one of which is short-circuited to act as a secondary to the eight primary poles, whilst the other is connected up to a disc-shaped commutator. A pair of brushes bears on this commutator, connecting it in series with the field circuit. On starting, the machine acts as a series motor, both armature and field magnetisations reversing simultaneously, thus giving a pulsatory torque always in the same direction. As the speed of the machine increases, the short-circuited secondary winding comes into action and gives a powerful torque which brings the speed up to synchronism. At synchronism, the commutator acts as a rectifier giving a pulsatory direct current to the rotor winding connected to it. This pulsatory direct current sets up direct magnetic poles in the rotor, which react on the A.C. field and make the machine run as a synchronous alternating motor with an internal rotating field-magnet. At synchronism, the short-circuited winding exerts no torque at all but serves, in connection with the self-induction of the rotor-windings, to smooth out, by the currents induced in it, the pulsatory magnetisation of the rotor-teeth and thus render this magnetisation practically constant. C. K. F.

865. *Motor Switches.* **C. F. Guilbert.** (Écl. Électr. 15. pp. 93–98, 1898.)—The author describes a number of switches for shunt motors. In one the shunt is permanently connected to the brush through a resistance, so that the shunt is never broken. A multiple switch connects the main on to various points on this resistance. As the resistance is cut out of the armature circuit it is put into the shunt circuit. The switch has an off contact. In another switch the shunt is never broken, but after switching off the shunt is short-circuited. In another the switch is held in the full-on position by an electromagnet which carries the shunt-current, but if the main current exceeds a certain value this retaining magnet is short-circuited by another electromagnet which is in the main circuit. The current at which the main magnet works can be adjusted. Two varieties of this switch are described. R. B. R.

866. *Leonard System of Motor Control.* (Elect. World, 31. pp. 463–466, 1898.)—A description of the electrical plant of the New York Athletic Club House is given, in which the elevators, four in number, are driven by electromotors controlled on H. W. Leonard's system of varying the supply pressure. A separate generator is used for the supply of each motor, the armatures being connected in series; the fields are excited from the lighting circuits, that of the motor being constant, while the generator field is

varied by means of a controller carried on the elevator car and connected by flexible cables. Reference is made to a description of the elevator machines in Elect. World, 21. pp. 643–646, and 22. pp. 684–685, 1897. A brief account is also given of the system of dumb waiters installed. A. H. A.

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867. *Protection of Electric Motors.* **H. H. Cutler.** (Elect. World, 31. pp. 469–470, 1898.)—The author points out that motors can only become dangerously hot by abnormal currents being allowed to flow for an appreciable time. The ordinary fuse is unreliable owing to the cooling effect of varying drafts of air. He then describes a form of enclosed fuse, the distinguishing feature of which is an enclosed air-chamber around the fuse, consisting of a gelatine capsule similar to those used for filling with medicine. The fuse proper is very short and contained entirely within the capsule; copper leads are connected to the fuse and lead out to the terminal caps through closely-packed sand or plaster-of-Paris. The capsule provides a definite amount of air within which the explosion takes place. The force of the explosion is taken up by the sand on each end, and as there is no air and but little metal to feed the arc it immediately goes out. He also describes a circuit heater which depends on the combined magnetic and heating effect of the current. The mechanical construction is similar to the usual type of magnetic circuit-breaker, the chief difference being that the magnet which releases the catch carries only a portion of the current, the rest being shunted by a shunt composed of material whose resistance increases very rapidly as it becomes heated. On starting a motor under load, both motor and circuit-breaker are cold, the resistance of the shunt is low and it carries the largest part of the current: as the current continues to flow the shunt resistance increases and more current flows through the magnet coil, which will finally act should an abnormal current last long enough to be dangerous. An extremely abnormal current or short circuit would cause the circuit-breaker to open instantly. In practice these circuit-breakers are generally so proportioned as to allow an excess current of 50 per cent. to flow for a second. Any current over 60 per cent. greater than the constant current which would finally open the circuit-breaker will do so instantly.

R. B. R.

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868. *Step-down Transformers for Niagara.* (Elect. World, 31. pp. 435–438, 1898.)—Four transformers have been installed in the Niagara-Buffalo transmission plant. Three are for actual service, and the fourth is held in reserve in case of accident. Each transformer has a capacity of 850 kilowatts. Three are connected together in a group, giving an aggregate capacity of 2550 kilowatts. The star connection is used on the primaries, the delta connection on the secondaries. The line-voltage is now about 11,000, but will eventually be increased to 22,000. The method of regulation adopted is novel, and is shown diagrammatically in fig. 1 for a single transformer. In each transformer there

is an auxiliary coil wound to deliver approximately 750 volts and a maximum current of 300 amperes. Loops are brought from this coil at regular intervals, and are connected to a regulator-dial. A 75-kilowatt series converter, which is wound for 750 to 240 volts, has its secondary coils in series with the secondary coils of the main transformer, while its primary is connected to the regulator. The regulator is so arranged that any loops from the auxiliary may be connected to the primary of the series transformer, so that the secondary will deliver from 0 to 240 volts, depending on the loops connected to the primary. By means of a reversing switch placed in the primary circuit of the series transformer, its secondary voltage may be added to or subtracted from the secondary voltage of the main transformer.

Fig. 1.

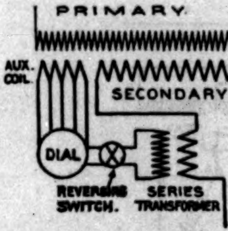
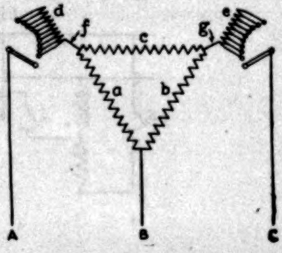


Fig. 2.



Although three-phase currents are delivered at the desired E.M.F., regulators on two phases and only two series transformers are used in each three-phase circuit. The method of accomplishing this is shown diagrammatically in fig. 2. *a*, *b*, and *c* are the secondary coils of the three transformers with delta connection; *d* and *e* are auxiliary coils in transformers *a* and *b*. Loops are brought out from the auxiliary coils, which are connected at *f* and *g* as shown. A, B, and C are the three secondary line wires. From an inspection of the diagram, it is evident that as the dial-handles attached to A and C are turned in corresponding directions through the same angle, the voltages in *a*, *b*, and *c* will all vary together by the same amount.

An efficiency test of one of the 850 kilowatt transformers gives the following results:—

Load.	Efficiency.
Full load.	98·46 %
1½ " "	98·35 "
¾ " "	98·41 "
½ " "	98·10 "
¼ " "	96·80 "
1/10 " "	92·70 "

W. G. R.

869. *Stationary Phase Transformers and their possible Applications.* **G. W. Meyer.** (Zeitschr. Elektrotechn. Wien, 16. pp. 189-193, 1898.)—The author gives an account of some recent devices for obtaining polyphase from single-phase currents by means of *stationary* phase-transformers. Rotary transformers may, of course, be used; but in that case one of the main advantages of alternating currents, viz. the possibility of transforming up or down by means of simple, cheap, and highly efficient apparatus, having no moving parts and requiring no attention, is sacrificed. One important application of such a stationary transformer would be in the case of an electric railway operated by three-phase motors, but supplied with a single-phase current—whereby the necessity of using two overhead conductors is done away with. An ingenious method of dealing with this problem has recently been patented by the Union-Elektricitäts-Gesellschaft. The three-phase induction motor M (fig. 1) is connected as shown to the two secondaries of an ordinary transformer, the middle point of whose primary winding is *at starting* connected

Fig. 1.

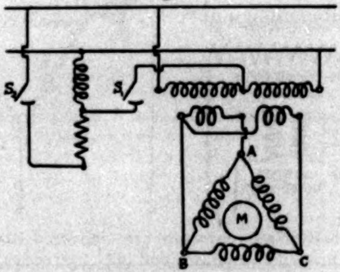
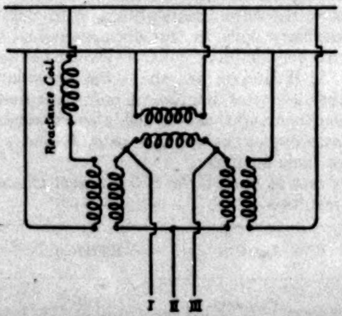


Fig. 2.



to the junction of a reactance-coil with a non-inductive resistance, these latter being joined across the mains by means of the switches S_1 and S_2. A phase-displacement is thus obtained which enables the motor to start, after which the switches S_1 and S_2 are opened. The rotor of M is provided with a three-phase winding, and the reaction of this is on the field *when the motor is running* induces an E.M.F. in the portion BC of the winding, so that the motor goes on running as a three-phase machine, although supplied with a single-phase current.—An arrangement patented by T. Marcher in 1895 is next described. It is shown in fig. 2, and is intended to provide two-phase currents between I and II, and I and III, for induction motors, while the ordinary lighting circuit is connected across II and III. The author advocates the use of stationary phase-transformers in combination with independent secondary distributing networks for lighting and power; the motors could thereby be worked at the maximum permissible pressure, which would not be limited by that of the lamps. A. H.

POWER DISTRIBUTION, TRACTION, AND LIGHTING.

870. *Cost of Electrical Energy.* **H. P. Elliott.** (Canad. Elect. News, 8. pp. 60–61, 1898.)—This paper consists of a detailed analysis of the cost of production of electrical energy as affected by the type of engine used, the cost of coal, and the nature of the load. The case is taken of a 350 kilowatt dynamo supplying energy for lighting; four types of engine, two values for the cost of coal, and three load diagrams are considered. A table of costs in detail is given, together with efficiency curves and load diagrams, and an account of the methods of calculation employed. The result obtained for the total cost per unit generated, with a load-factor of 46 °/₀, and using the best type of engine, is 1·056*d.* with coal at 12*s.* 6*d.* per ton, or 1·32*d.* with coal at 21*s.* per ton. The author concludes that the load-factor has a much greater influence upon the cost of production than either the efficiency of the engines or the price of coal. A. H. A.

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871. *Power Transmission in Mines.* (Zeitschr. Elektrotechn. Wien, 16. pp. 30–34, 41–48, 58–60, 1898.)—In the introductory part of this paper, the author compares the relative advantages and disadvantages of steam, compressed air, hydraulic, and electrical power transmission. The remainder of the paper is of a purely descriptive nature, and is concerned with electrically-driven pumps, fans, winding-engines, haulage machinery, rotary and percussion drills. A. H.

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872. *New System of Distribution.* **C. F. Guilbert.** (Écl. Électr. 13. pp. 486–489, 1897.)—One of the chief difficulties attending distribution of energy by tri-phase currents is due to differences of load on the three circuits. The author proposes to overcome this difficulty as follows:—

Divide each secondary winding of the transformers into five equal parts *a*, *b*, *c*, *d*, *e*. Connect *a*, *b* and *c*, *d* in parallel; join these multiple circuits in series with each other and in opposition to *e*. Each of these three circuits will take from the three primary circuits equal quantities of energy.

The author then proceeds to show that the solution only holds good for a particular phase difference between the secondary currents and E.M.F.s, and so will not, in general, be applicable to practice. W. G. R.

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873. *Thermal Efficiency of Electrical Generating Stations.* **W. S. Aldrich.** (Écl. Électr. 15. pp. 25–27, 1898; Amer. Soc. Mech. Eng. 1897.)—The efficiency of electrical works expressed in terms of watt-hours per pound of coal consumed is always much less than that of other works. According to a table given by

the author, the average value in 1897 was 156·4 watt-hours per pound, whereas in mills, etc., the result was about 450. The author suggests that a comparison made on the basis of watt-hours per calorie expended, or watt-hours per pound of steam used, would be more just, and questions the reality of large losses at low loads. A. H. A.

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874. *Thury's System of Continuous-Current Power Transmission.* **C. Wieshofer.** (Zeitschr. Elektrotechn. Wien, 16. pp. 5–10, 1898.)—The main advantage of alternate over continuous currents for long-distance power transmission lies in the ease of transformation and the greater structural simplicity of the machines. Against this, however, must be set the phase-displacement between E.M.F. and current and the fact that all ordinary forms of alternate-current motors tend to run at or near the speed of synchronism. The author describes Thury's system of power transmission by means of continuous currents; it is in use at the Val de Travers (1,000 H.P., 10,400 volts, 21 miles), Chaux da Fond and Lock (3,200 H.P., 14,400 volts, 25 miles), Brescia (500 H.P., 7000 volts, 25 miles), and other places. The high E.M.F. is obtained by coupling a number of series-wound generators in series. The drum-winding is used up to 2400 volts, and above that the gramme. Each generator is carefully insulated, the bed-plate resting on porcelain insulators embedded in the foundation by means of a cement of sulphur and powdered glass. The coupling between generator and prime mover consists of a pair of thick rubber disks connected by bolts. Two short-circuiting switches are provided for each generator, one being a hand-switch, the other an automatic switch controlled by a cam on the dynamo-shaft so shaped that when the direction of rotation is reversed the switch immediately short-circuits the machine. The power is received at the distant station by a number of similar series-wound motors connected in series, and used either directly as such or coupled to constant-potential dynamos. Each motor is provided with a special regulator which maintains the speed constant within 2 °/₀ by acting on a shunt of variable resistance connected across the field. A. H.

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875. *Electric Works at Jemmapes.* **A. Soulier.** (Ind. Élect. 7. pp. 107–114 & 130–140, 1898.)—This is a detailed and illustrated description of the installation at Jemmapes, where the distributing system has been changed from three to five wires. The chief point of general interest is the description of the generating plant, which is capable of developing over 27,000 H.P. W. G. R.

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876. *Multiphase Plant in Railway Shops.* (Elect. World, 31. p. 439, 1898.)—The new locomotive and car shops of the Boston and Maine Railroad, at Concord, N.H., has been installed and isolated plant equipped with multiphase apparatus.

The motors are controlled entirely by means of a quadrant-shaped regulator placed in the primary circuit. Two rows of segments of the regulator being respectively connected with two auto-transformers, thus controlling the speed of the motor by altering the voltage between the primary terminals, since the torque on the secondary of the motor varies as the square of the applied voltage. This method of regulation is similar to, and as successful as, the usual regulation of a series-direct current motor. W. G. R.

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877. *Japanese Cruiser 'Chitose.'* (Elect. World, 31. pp. 442–444, 1898.)—In this vessel, now building for the Japanese navy, a most complete electric installation is being provided, not only for the complete lighting of the vessel, but also electric power hoists for the ammunition. The electric current is produced by three dynamos, each of 32 kilowatts capacity, directly coupled to compound balancing engines. The dynamos are compounded for a constant potential of 80 volts, and are required to deliver their rated output for four hours with a rise of temperature not exceeding 60° F. above that of the surrounding atmosphere. The results of tests are given. The article contains sectional diagrams of the ammunition-hoists. W. G. R.

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878. *Mechanical Features of Electric Traction.* **P. Dawson.** (Engineering, 65. pp. 31–32 & 91–94, 1898; also discussion, 64. pp. 582–583, 1897, & 65. pp. 195–197, 1898.)—In this paper the author describes and discusses the principal details of construction of electric tramways, chiefly with reference to American practice. Numerous tables, curves, and figures are given, including statistics relating to the progress and present state of electric traction in Europe and America; sags, stresses, and other data of span-wires; dimensions and strength of tubular poles; weights of engines and fly-wheels; dimensions, efficiency, etc., of electric-tramway generators; torque and efficiency of motors; and tests of the working of a large generating station. The author emphasises the importance of sound joints in the poles, which have to sustain a side stress of from 500 to 4000 lbs.; details of the method of construction are given, with the tests applied. The design of the car-trucks is described at considerable length, and a list of the conditions to be fulfilled by them in tramway working is given. Various methods of rating traction-motors are discussed, and their special features are detailed. The rating and construction of the engines are considered, and shaft-governors strongly advocated. It is stated that in a large station, of which detailed tests are given, the minimum consumption of coal is 1·67 lbs. per I.H.P. hour or 2·48 lbs. per E.H.P. hour. The design of fly-wheels is discussed, with illustrations of built-up wheels. The discussion turned chiefly upon comparisons of American and English practice. A. H. A.

879. *New Heilmann Electric Locomotives.* **C. Jacquin.** (Écl. Électr. 13. pp. 289–305, 1897.)—This is an illustrated description of the new electric locomotives constructed for the Havre line. Two new locomotives have been constructed, each capable of developing 1350 horse-power. Each engine is driven by eight electric motors connected in parallel. The table given below shows the weights of the different parts of these locomotives:—

Body of locomotive	34·0 tons.
Boiler full of water	23·7 „
Steam-engine &c.	9·3 „
Dynamos and motors	40·0 „
Extras	3·0 „
Water and coals	14·0 „
Total weight of locomotive and accessories	124·0 tons.

The older locomotives on the same line have a total weight of 117 tons, and could only develop 700 horse-power. W. G. R.

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880. *Glasgow District Subway.* (Elect. Engin. 21. pp. 70–72, 102–103, 134–136, 172–173, 198–199, 293–295, & 326–328, 1898.)—It is now just ten years ago since the first scheme for the above subway was promoted (viz. in 1887), and the proposals then put forward were for a line to be worked mechanically by cable and embracing only the northern half of the present circle. In 1889 the Company obtained powers to make a tunnel under the River Clyde at Finnieston. The route of the line is, generally speaking, a circle, tapping the chief business and residential portions of the city, and passing twice under the Clyde. The total length of the line is 11,527 yards, or roughly 6½ miles of double track. The tunnels consist of two endless tubes, 11 feet diam., lying side by side.

The reasons why electric traction was not employed are discussed in this paper. Whenever electricity is employed, traction is performed by adhesion—the grip of the wheels on the rails. This, on the Subway, would entail the cars or motors being made sufficiently heavy to surmount the steep gradients under the river, and therefore unnecessarily heavy for traction on the rest of the road. It being almost impossible to get sufficiently powerful motors underneath the cars in the small available space, electric locomotives would be the only other alternative, and these would have to weigh at least 15 tons. Heavy rolling-stock would require heavy permanent way, which, under traction by adhesion, would require more frequent renewal than would be necessary under traction by cable. On the other hand, the cable-system has several advantages peculiar to itself. All the cars on any one cable are thereby linked to each other; so that the cars going downhill at one point assist in pulling the cars which, at the same time, may be going uphill at another part of the line, thus greatly reducing the demands on the hauling engine. The greater the number of cars, the greater this compensation becomes. The above reasons are those which at the time induced the engineers to adopt cable in preference to electric traction.

Then came considerations as to lighting both the cars and the stations, and also as to other power-requirements, such as lifts, pumps, etc.; and when all these requirements were considered together, it was decided to adopt electricity for all the above auxiliary requirements, requiring plant having an output of 146,000 watts + 25 per cent. extra for lighting, both arc and incandescent, and power-work over a distance of 6½ miles.

The electrical generating plant includes 4 engines of 120 B.H.P. The dynamos are of the inverted horseshoe type, shunt-wound, direct-coupled to the engines, and each capable of developing 79 kw. The armatures are of the gramme type. Two of the dynamos are arranged for running on the outside wires of a three-wire system, and are wound for an output of 145 amperes at 540 volts; while the other two machines, intended for running in series across the three-wire system, have an output of 220 amperes at 270 volts.

The main switchboard consists of three enamelled slate panels. The main circuits, after passing through automatic cut-outs, are connected to main double-pole throw-over switches, enabling either of the low-tension machines to be put on either side of the three-wire system. The fuse-terminals are arranged so that a plug connects them direct on to the bus-bars, and they are all arranged in duplicate, so that in the event of a fuse blowing a spare one can be immediately plugged in. On each of the feeders running to the four feeding-points are arranged a special combination volt and ammeter, which shows, by means of two pointers on the same scale, both the current in the feeder and the voltage at the power-station end of the feeder. The scale is marked off in amperes, and the pressure-half of the instrument is so adjusted that when its needle is pointing to the same reading on the scale as the current-indicator, the voltage at the station end of the feeder is the correct amount above the normal to give the normal voltage at the other end of the feeders. The current and pressure portions of the instrument are precisely similar, but are totally distinct from one another, the two needles showing one on either side of a vertical scale. A diagram is given of the arrangement of connections on the switchboard.

The distribution throughout is carried out on the three-wire system, the lamps being 230 volt, with a normal 460 volts across the two outside wires. It is claimed for this installation that it is the first station to be laid down on the three-wire system and originally designed for using 230-volt lamps, although it was quickly followed by others.

The cables are all carried on the inner wall of the inside tunnel, on malleable iron bracket supports. The cables are simply laid along these brackets, and then strained up and secured by means of split wooden blocks bound on to the cable close against the bracket. By this means sag is prevented.

Dampness at first gave considerable trouble, both with the switchboards and with the wiring. All the fittings are mounted upon paraffined teak, as a film of moisture cannot readily form on this material when so treated. All the terminals, too, are mounted on turned teak pedestals well paraffined. Various methods of running the wires were tried, and the most satisfactory plan has been found to be to carry them on small insulators overhead, fixed to the roof of the stations. In some of the drier stations wood casing is still used to a considerable extent.

All the electric-light connections at the various stations are of sufficient size to carry double the number of lamps, it being the Directors' idea to supply current to all their tenants at a cheap rate.

For the purpose of illuminating the cars a pick-up system was adopted, in preference to the use of accumulators, owing to their adding a great dead load to the haulage-engines. It was decided to use two conducting-rails, and to make no attempt to bond the permanent-way rails with a view to using an earth return. These rails are placed along the side of the tunnel, there being not enough clearance at the top, and the space between the rails being occupied by the rope-gear. The general arrangement of the rails is shown in an illustration, the fitting-up of which necessitated the use of 23,000 insulators and 250,000 bolts. The current is picked up from the rails by a somewhat elaborate form of trolley-gear attached to the cars, specially designed to maintain contact on the trolley-rails, irrespective of the motion of the car due to a variation of load or other causes that tend to exert influences on the springs. A drawing is given showing the device employed, consisting of a double trolley-pole, to ensure a steady light.

The interior lighting of the cars consists of four 16 c.p. lamps on the roof. There is a single white headlight with a 16 c.p. lamp, and at the rear there are two red tail-lights, with clear glass inside, which also serve to light the lobby of the cars.

In such an undertaking the pumping arrangements were found to be of paramount importance, and a full description is given of the systems employed.

Up to the present only the Kelvinbridge Station has been fitted with electric lifts, of which the general arrangement is shown in a diagram, and working on the Easton-Anderson and Goolden system. The switch is actuated by a hand-rope passing through the lift-cage, and automatic stops are provided for preventing the cage from over-running; also an emergency switch worked by the cage, should the latter over-run in consequence of the hand-rope breaking. A magnetic break is provided, so arranged that when the current is on the break is released, but immediately the current is cut off the break is put on.

In designing the signalling arrangements, the point aimed at was to reduce the labour-bill. It was therefore decided to make the whole of the signalling arrangements semi-automatic, and as simple as possible consistent with the safe working of the traffic. The line is worked on the absolute block system, but without signalmen, the station-masters at their respective stations doing the requisite manipulations. The automatic arrangements and system of working are fully described. There is also an independent system of signals, by means of bells and plungers worked by hand.

L. J. S.

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881. *Test of Chicago Accumulator Tramway*. (Elect. Rev. 42. pp. 311–313, 347–348, 382–384, 1898; and Street Rly. Rev.)—The line consists of 23 miles of track, with a maximum gradient of 9·3 per cent. over a distance of 371 feet, on which it has been found necessary to instal a counterweight system. The whole plant has been designed upon the most approved lines, thus giving a fair trial to accumulator-traction. The batteries are charged off three circuits at different pressures, which are supplied by four six-pole 190-kw. shunt-wound Walker dynamos, coupled to Willans condensing engines. The boilers are water-tube, fitted with mechanical stokers, and supplemented by a Green's economiser. Each battery consists of 72 cells, having five negatives of the "chloride" type and four positives of the "Tudor" or "Manchester" type. The weight of a cell, including plates, electrolyte, and hard rubber jar, is 100 lbs.; the total weight of battery and tray being 7800 lbs. The battery-room is under the car-shed; and the batteries, which are suspended on the car-trucks, are rapidly changed by means of elevators. The discharged batteries are charged successively at 160, 172, and 176 volts. The cars are provided with one 50 H.P. Walker motor. The controllers have five points, by which the four parts of the battery may be coupled all in parallel, half in series and half in parallel, the whole in series with or without resistance, and finally the whole in series, the motor-field being shunted. During last summer 20 motor-cars were operated, often with trailers.

The tests of the road were carried out by G. A. Damon and Prof. Gaylord. The average all-day efficiency (indicated to electrical H.P. at switchboard) amounted to 79·3 per cent. The coal had a theoretical evaporative-power of 10·5 lbs. of water, and actually evaporated 6·6 lbs., giving an efficiency of 62·86 per cent., the boiler being underloaded. The economiser was unsatisfactory, owing to unfavourable conditions. The pumps required 5·11 per cent. of the total fuel for their working. The test showed that the engines used 18 lbs. of steam per I.H.P., but they were not working under the best conditions. The total station-efficiency from coal-pile to switchboard was found to be 5·58 per cent. The cost of fuel per net kw.-hour at switchboard is 0·611 cent, this high figure being due to the fact that a high price is paid for a poor coal. Detailed figures are given of the engine and boiler trials. In order to test the performance of the batteries, a complete log was kept of the charging-room, under somewhat varying conditions, upon two days. The following summary is given:—

Date of test	Nov. 5th.	Nov. 26th.
State of weather	Rainy.	Rainy and cold.
Kw.-hours delivered to switchboard	2,638	2,895
Kw.-hours used by cooling-tower motor	151	174
Net kw.-hours delivered to charging bus-bars	2,487	2,721
Total number of car-miles	1,821·8	1,668·4
Kw.-hours on switchboard per car-mile	1·37	1·63
Pounds of coal per net kw.-hour	6·9	6·44
Price of coal per ton	$1·90	$1·90
Cost of coal per net kw.-hour	0·00655	0·00611
Cost of coal per car-mile	0·00897	0·00996

More energy was required on the second day, owing to a coating of ice on the rails.

In order to determine the efficiency of the batteries a test was carried out upon a 13½-ton car (including batteries), having seating-capacity for 28 passengers. The load consisted of nine observers, the motorman, and conductor; and the car was run as nearly as possible under the conditions of an actual trip, at an average speed of 11·84 miles per hour. The results over a practically level road, with a battery that had operated over 8000 miles, were an efficiency of 53·6 per cent. for the first charge and discharge, and 62·32 per cent. for the second charge and discharge. The second of these figures is the more reliable, and the difference between the two is due to the fact that the charging of the battery was left to the regular operators, who used their judgment as to the pressure, and as to when the battery was fully charged. The maximum discharge-rate during acceleration was found to be 220 amperes per cell, all the cells being in series.

It is pointed out that these tests do not demonstrate the best results that may be expected from accumulator-traction, as they were not made with that object. With the introduction of improvements, the cost of fuel per car mile should fall below 0·5 cent. Figures of maintenance would be premature. The batteries have operated from 8,000 to 14,000 miles, and are standing the service remarkably well. W. R. C.

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882. *Three-Phase Traction at Zermatt.* **W. Hönig.** (Zeitschr. Elektrotechn. Wien, 16. pp. 89–92, 1898.)—The paper contains a description of the electrical equipment of the Zermatt-Gornergrat mountain-railway. The author is of opinion that, in spite of the objections raised against three-phase traction on the score of two overhead wires, the system is bound to come into more general use. The total length of the line under consideration is about 5½ miles, the generating station being about a mile distant from Zermatt. The generating plant consists of three sets of 250 H.P.

three-phasers (5400 volts at 40 ~ per sec.) coupled elastically to Pelton water-wheels running at 400 revs. per min. Two sets are always in use, the third being a reserve. The power is transmitted along three 5½-mm. wires to three transformer sub-stations of 180 kilowatts capacity each, and is there transformed down to 540 volts, at which pressure it is fed into the line (two 8-mm. wires). Each locomotive carries two three-phase non-synchronous motors of 90 H.P. each, running at about 800 revs. Double-reduction helical gearing (giving a ratio of 12:1) is used, the pinions driven by the motors working on a rack laid in the centre of the track. Vignoles rails, with Chicago rail-bonds, are used. The steepest grade is 1 in 5. The rotor-winding is connected to three contact-rings, and by means of a resistance common to the two rotors the speed may be varied. The motors will start under full load without drawing more than the normal current from the line. When running down-hill the motors may act as generators, whereby the plant at the generating station might reach a dangerous speed. This is provided against by an artificial load at the station, which is automatically thrown into circuit as soon as a certain limiting speed is reached by the water-wheels. The railway is to be opened for traffic in July. A. H.

883. *The Walker Tramway Controller.* **J. Reyval.** (Écl. Électr. 15. pp. 45–48, 1898.)—This controller differs from the ordinary types fitted with magnetic blowers, inasmuch as each contact where an arc can take place is fitted with a special magnetic circuit consisting of solenoids without iron. The controller is so constructed that there is no uninsulated piece near the contacts where the arc is formed; so that no dangerous earths can take place. The arc, moreover, is blown in a direction perpendicular to the axis of the cylinder, and can therefore neither burn the insulation nor establish a short-circuit between two adjacent contacts. The magnetic flux produced by the solenoids is proportional to the strength of the current through them, and consequently to the arc to be blown; whereas, with those blowers employing electromagnets wound on polar projections, the saturation of the iron limits the action of the blower when the strength of the current is very strong and at the moment when the arc is most dangerous. The solenoids are only put in circuit at the moment of coming into action, thus effecting a saving of energy. The brushes and contacts are, moreover, left uncovered in order that they may be easily inspected and repaired. The weight of two such controllers and one rheostat, for a car of 25 to 30 H.P., amounts to 220 kg. L. J. S.

884. *Efficiency of Tramcar Motors.* **E. G. Fischinger.** (Elektrotechn. Ztschr. 51. 1897.)—Experiments were made on one

Constant Pressure, 500 volts.

Motor with Reduction Gearing.										Motor alone.							
Exciting current, full armature current.					Exciting current, half armature current.					Exciting current, full armature current.				Exciting current, half armature current.			
Current, in amperes.	Speed		B.H.P.	Efficiency, °/₀.	Current, in amperes.	Speed		B.H.P.	Efficiency, °/₀.	Current, in amperes.	Speed of motor, in revs. per min.	B.H.P.	Efficiency, °/₀.	Current, in amperes.	Speed of motor, in revs. per min.	B.H.P.	Efficiency, °/₀.
	of motor, in revs. per min.	of car, in miles per hour.				of motor, in revs. per min.	of car, in miles per hour.										
76·2	376·5	7·0	34·2	65·7	77·0	452·0	8·4	40·8	77·8	71·0	385	33·3	69·0	74·0	480	41·8	83·0
70·0	384·0	7·1	32·0	67·0	71·8	459·0	8·6	38·4	78·0	65·0	400	32·2	73·0	69·0	485	39·0	83·0
64·8	394·0	7·3	30·1	68·5	67·0	469·0	8·7	35·9	78·0	59·8	412	30·2	74·0	64·2	495	36·3	83·0
59·5	404·0	7·5	27·9	69·0	62·8	482·0	9·0	33·5	78·0	54·8	418	27·8	75·0	59·7	510	33·7	83·0
53·8	416·5	7·8	26·2	71·8	58·3	497·0	9·3	31·2	78·8	49·3	436	25·8	77·0	54·0	523	30·8	83·8
48·6	432·0	8·1	24·0	72·5	53·8	514·5	9·6	28·6	78·5	44·0	452	23·6	79·2	49·2	538	28·2	84·2
43·6	447·0	8·3	21·6	73·0	48·4	537·0	10·0	26·2	79·5	38·8	466	21·3	80·2	43·6	561	25·5	85·6
38·2	462·0	8·6	19·2	74·0	43·3	560·0	10·4	23·4	79·5	33·8	485	18·6	80·5	38·8	586	22·4	85·0
33·4	479·5	9·0	17·1	75·0	37·4	587·0	10·9	20·4	80·0	29·0	508	16·9	80·7	33·7	621	19·6	85·0
28·4	504·5	9·4	14·1	73·0	32·0	627·5	11·7	17·4	80·2	23·3	535	13·1	83·0	28·5	675	16·5	84·8
23·7	547·0	10·2	11·4	71·0	26·2	693·0	12·9	14·4	81·0	18·7	575	10·0	78·5	23·7	763	13·3	82·0
18·0	612·5	11·3	8·5	69·5	20·8	798·0	14·9	11·0	77·5	13·6	650	6·8	73·5	18·3	940	9·8	79·0
15·8	647·5	12·1	6·7	63·0	18·3	904·0	16·8	9·4	75·2	11·0	745	5·2	69·8	15·8	1095	7·7	72·0
12·9	738·0	13·7	5·2	59·0	15·2	1069·0	19·9	7·4	71·5	8·4	940	3·3	57·0	11·7	1460	4·4	55·0
10·2	939·0	17·4	3·3	47·0													

of the motors in use on the Mulheim Tramway, measurements being taken after the motor had worked 8 hours. The results are given in the table (p. 463). The gear-wheels were lubricated with valvoline oil, and showed an efficiency of from 90 to 97 %, the smallest efficiency being when transmitting large powers at small speed. With grease as lubricant the efficiency was less, except in the case of small powers at slow speeds. G. H. Ba.

885. *Electric Traction on Canals.* (Elekt. Runds. 15. p. 111, 1898.)—A brief account of experiments in this direction conducted in France. Two methods have been tried. In the one, a special form of electric car is propelled along the towing-path, and is connected to the barge by a rope. In the other, a detachable screw-propeller worked direct by an electric motor is used. The current in either case is supplied by an overhead conductor and trolley. A. H.

886. *Electric Car-Wiring.* **E. C. Parham.** (Amer. Electn. 10. pp. 171–172, 1898.)—In previous articles the author dealt with all the connections on the car, excepting several inside the controller. In order to proceed with the test the author deals with the car-wiring diagram of the system in question, showing the order in which the current from the trolley enters the several devices on the car, and the relation borne by the terminals of these devices to the lettered or numbered binding-posts on the controller. The order in which the current enters the several devices depends on whether the armature or the field is earthed. Some systems earth one and some the other. The advantages and disadvantages are discussed. On all systems of wiring it is customary to designate the terminals of the various devices by means of the initial letters of their names. These letters are further modified to distinguish the different leads coming from the same device, and, further, the letters are stamped on the controller collecting posts, so that the most inexperienced wireman may readily see to what part of the controller the variously tagged hose wires should go. An illustration is given of the most common system of lettering, and examples given of the various faults which may happen and the methods of locating them. Points about an equipment most apt to give open circuit troubles are:—poor connection between trolley-stand and roof-wiring; defective hood-switch; loose controller connection, controller finger making no contact; resistance-coil burnt out; motor field or armature lead burnt off; a blown fuse; weak brush springs, short brushes, brushes tight in holders, or absence of brushes altogether; ground-terminal burnt off; loose two-way connector; and a dirty or dead rail. The symptoms indicating most of these faults are dealt with. L. J. S.

887. *Welsbach Incandescent Lamp.* **A. M. Gibson.** (Elect. Rev. 42. pp. 504–505, 1898.)—The author gives some particulars regarding Welsbach's recent invention. Two bodies—osmium and thoria—are used in the preparation of the lamp filaments. The efficiency of such lamps has been stated to be less than 2 watts per candle. Several methods of preparing the filaments are described. The author states that although the electrolytic method of obtaining a coating of osmium or thoria is by far the cheapest, this method is only vaguely alluded to in Welsbach's patent specification, while those described by him are little better than laboratory processes quite impracticable on a large scale. He concludes by saying that the facts on which Welsbach's patent is based have been known to experts for some time past. A. H.

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888. *Welsbach Incandescent Lamp.* **J. R.** (Écl. Électr. 15. pp. 190–192, 1898.)—In a recent Hungarian patent Auer v. Welsbach describes various methods of coating or forming glow-lamp filaments with substances capable of increasing their efficiency, as in incandescence gas-lighting. Metallic osmium and thoria (thorium oxide) are the most suitable materials. To obtain a filament of osmium a fine platinum wire (0·02 mm. diam.) is repeatedly heated to redness either in an atmosphere of osmium tetroxide and hydrocarbon vapour, or after immersion in a solution of osmic acid and osmium sulphide (*sic*). The adherent very thin layers of metallic osmium thus deposited in the course of about 100 operations form a tough tube, from which the platinum core is then volatilised by means of a strong current. Instead of platinum, animal or vegetable fibres may be used; they are dipped in a solution of osmic acid containing sugar or gum, and then dried and heated to redness in a reducing atmosphere. The filaments thus obtained are finally bent into shape, and heated repeatedly by a strong current in alternate atmospheres of moist hydrocarbon and osmium tetroxide vapours. Filaments may also be made of a paste of guncotton and amorphous osmium or osmium tetroxide, and an electrolytic method of depositing osmium is mentioned but not described. Platinum wires are coated with thoria in the same way as with osmium, by alternately moistening the wire with thorium nitrate or other decomposable salt, and heating; but in this case the platinum core is permanently retained, and it is noteworthy that thus coated it bears a temperature and current which would fuse an uncoated wire. An alloy of platinum and osmium, with or without other metals of the platinum group, may be substituted with advantage. The efficiency of some of these new "incandescence" glow-lamps is stated to be as high as 2·0 to 1·5 watts per candle-power. J. W.

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889. *Enclosed Arc-lamp of the Allgemeine Elektricitäts Gesellschaft.* (Zeitschr. Elektrotechn. Wien. 16. pp. 140–141, 1898.)—

The details of construction of this lamp are not given, except in so far as they can be gathered from two photographs and a description of the method employed of inserting fresh carbons in the lamp. The time of burning of a 4-A. lamp is about 150 hours, a 5-A. lamp about 130 hours, a 6-A. lamp about 110 hours, when the lamps are burnt in periods of about 5 hours at a time. The potential difference of the arc is about 75 V., a resistance being generally arranged in series with it, sufficient to enable the lamp to work on 100–110 V. circuits. For the upper carbon a solid (homogeneous) carbon 13 mm. dia. and 300 mm. long is employed; the lower carbon also consisting of a solid carbon 13 mm. dia., but 150 mm. long. It has been found to be important that the inner globe and carbons should be thoroughly dry, otherwise the light flickers. C. K. F.

TELEGRAPHY AND TELEPHONY.

890. *Telegraphy.* **S. P. Thompson.** (Soc. Arts Journ. 46. pp. 453–460, 1898.)—Under the heading of "Telegraphy across space" three generic systems are considered:—(1) Conduction methods, depending upon the use of water-areas or the earth as a means of conveying electricity from sender to receiver. (2) Induction methods, electro-static and electro-magnetic. (3) Hertz-wave methods. The paper includes useful historical data, and particulars of distances traversed by the various systems. R. A.

891. *Signalling by Rotating Magnetic Field.* (Elettricità, Milan, 17. pp. 199–203, 1898.)—This article describes an apparatus devised by the Allgemeine Elektricitäts Gesellschaft of Berlin for the transmission of telegraphic messages. The transmitter is a generator of polyphase currents, and consists essentially of a coil in the shape of a Gramme ring, with three line-wires attached at points 120° apart. The current from a battery, not necessarily of constant electromotive force, is supplied to contacts at the ends of a rotating diametral arm, and sets up sine-currents of different phases in the three line-wires. These currents are sent to the receiving instrument and conducted to three electromagnets arranged so as to give a rotary magnetic field; a magnet pivoted in this field sets itself in a direction corresponding to that of the rotating arm of the transmitter. If the latter be pointed to any letter or sign on the circumference of the transmitter, the magnet of the receiver will indicate the same letter or sign on the circumference of the receiver. Separate transmitting and receiving instruments are depicted, also a diagram of an instrument in which both functions are combined. It is pointed out that the system can be applied with advantage in signalling from the deck to the engine-room, or other parts, of a ship. J. L. H.

892. *Hertz Waves and Wireless Telegraphy.* **O. Murani.** (Elettricità, Milan, 17. pp. 231–234 & 245–247, 1898.)—An abstract by Prof. A. Volta of the author's paper read before the Italian Electrotechnic Association at Milan. It contains a brief description of the theory of electromagnetic waves and an account of the experiments of Hertz; this is followed by a short sketch, in historical order, of discoveries and researches which have contributed to the success of the recent practical developments by Marconi. J. L. H.

893. *Rotary Decoherer.* **H. Rupp.** (Elekt. Zeit. April 14th, 1898, p. 237, & Elect. Rev. 42. p. 535, 1898.)—The filings-tube is rotated on its principal axis by the motion of the Morse slip. Contact is made by small brushes, one at each end of the tube. This apparatus takes the place of the electric tapper-back. A sketch is given to show the switching arrangements for the calling-up circuit and the Morse instrument. R. A.

894. *Telephone Call System.* (Elekt. Runds. 15. p. 97, 1898.)—The following arrangement, introduced by R. Stock & Co., of Berlin, does away with the necessity of any talking on the part of the operator in a telephone exchange. In front of a microphone at the exchange is placed a small electric trembler giving about 4 beats per second. The secondary of the microphone induction-coil is connected on one side to earth, and on the other to a metallic bar supporting the front row of subscribers' plugs. When a subscriber calls up, the operator inserts the corresponding back plug into the subscriber's jack, and thereby earths his line through the microphone-and-trembler signalling arrangement. The subscriber is thereby advised that he is being attended to. The operator immediately afterwards lifts the front plug, and by holding a notch cut in it against a metallic ring connects her listening apparatus to the calling subscriber's line, while the signalling arrangement is at the same time disconnected. The cessation of noise in his receiver tells the subscriber that the operator is ready to receive instructions, and he states the number of the subscriber wanted. The operator then inserts the front plug into the jack of the subscriber required, and by pressing a key once more momentarily connects the calling subscriber's line to the signalling apparatus. He then knows that through connection has been established. Should the subscriber wanted happen to be engaged, the operator simply removes the back plug from the calling subscriber's jack and then replaces the front plug on the contact-bar. The calling subscriber therefore receives no second signal, and interprets this to mean that the subscriber wanted is engaged. A. H.